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NASA

SPACE SYSTEMS TECHNOLOGY MODEL

VOLUME I

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System/Program Descriptions and Technology Needs

May 1980

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Code RS
NASA Headquarters
Washington, D.C. 20546

NAS 1.2:

Introduction
PART A: System Program Summary
System/Program List Schedule
PART B: System/Program Descriptions
Planetary
Astrophysics
Solar Terrestrial
Life Sciences
Resource Observation
Global Environment
Communications
Space Transportation
Utilization of the Space Environment
OAST Instrument Systems
PART C: Technology Requirements Summary

NASA

Space Systems Technology Model

VOLUME I: SYSTEM/PROGRAM TECHNOLOGY NEEDS

May 1980

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INTRODUCTION

This document is the second issue of the Space Systems Technology Model. This issue received NASA-wide inputs and coordination; the first issue was constructed solely for OAST internal usage. This Model will be revised and published on an annual basis. It contains NASA system and program requirements, technology trends, and forecasts for space technology. The Model provides a base of information for guiding technology development for future systems and programs. It also displays the expected availability of technology improvements to enable and/or enhance future missions.

PURPOSE OF THE MODEL

The purpose of the NASA Space Systems Technology Model is to serve as a reference for: planning technology programs and options; identifying technologies required for planned and potential future missions; assessing ongoing technology programs; and providing a technology reference source for mission planning. Ascertaining technology requirements for planned and future missions assures that the focus of technology programs is coupled to the overall goals and missions of NASA.

The system technology needs and requirements presented in the Technology Model do not constitute official agency plans, but may be used in their developments. The Model is a broader menu of candidate and opportunity systems and programs for the future than current funding expectations will allow.

GENERAL DESCRIPTION

The three volumes of the Model treat systems, programs, and technology from the present to reasonable limits of projection.

Volume I contains those systems and programs which the NASA program offices endorse as being within their ten-year planning horizon.

Volume II contains trends and forecasts of space technology.

Volume III provides information about innovative systems, programs, and technology. Part A presents systems and programs which are validated by program offices, but which are either beyond the ten-year planning period or are still deemed speculative. Part B systems and programs derive from sources other than the program offices and, as such, are considered more speculative than Part A missions. Part C presents emerging technologies with little-to-no historical trend, and provides best-possible forecasts of their potential.

The information in the Model has been assembled from a variety of written and oral sources. Validated information contained in the Model has been identified by tracable, formal reference to the responsible NASA Headquarters office. The emphasis is on quantitative descriptions where possible.

The elements presented in the Model include:

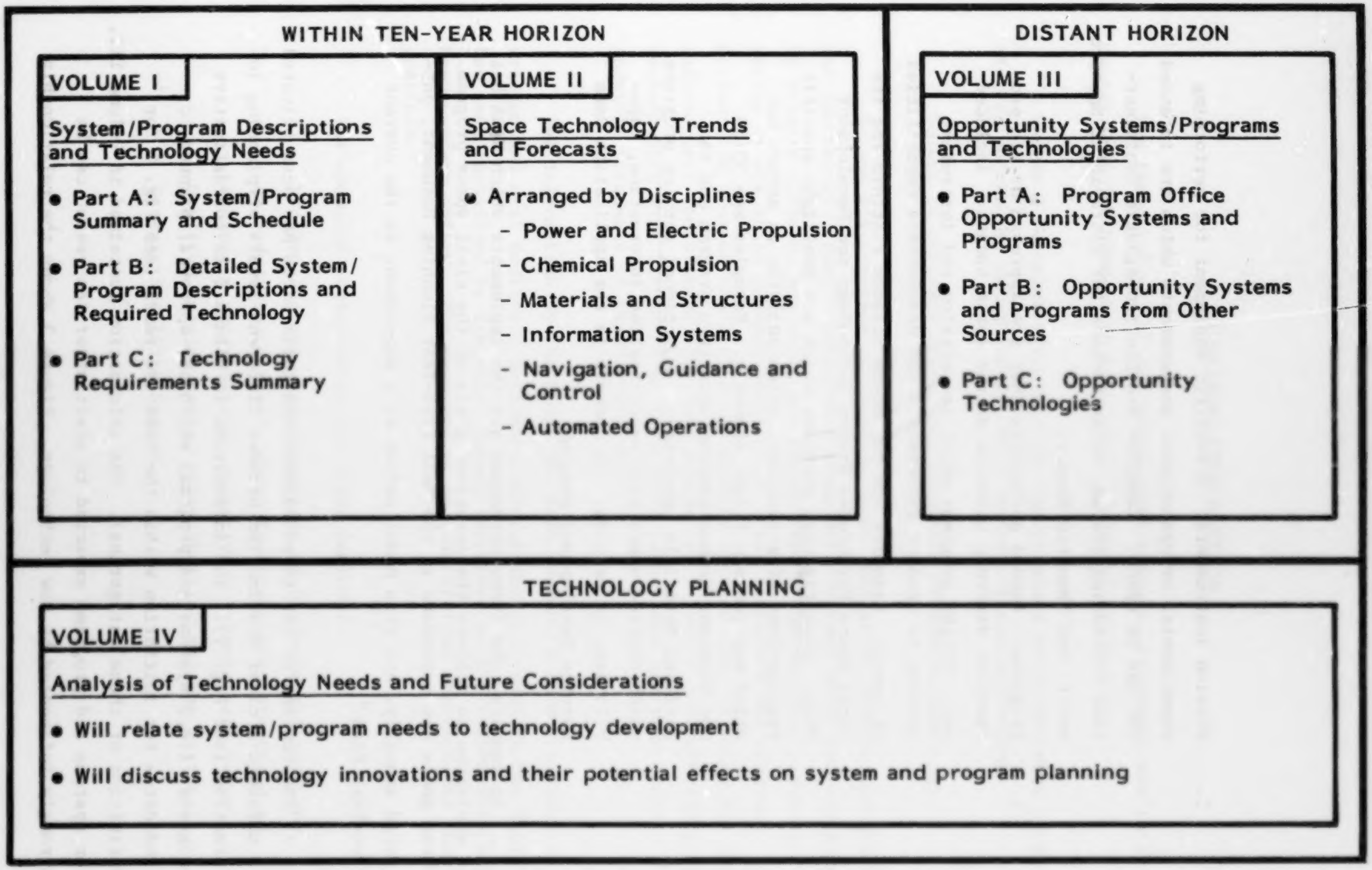
1. Mission Systems. An assemblage of hardware and software, ground- or space-based, whose functions are integrated to achieve a program-level objective. Examples are Venus Orbiting Imaging Radar, Space Shuttle, and the National Oceanic Satellite System.

2. Mission Instruments. Scientific equipment for performing experimental or operational measurements which are intended for use in space. Examples are Electromagnetic Containerless Processing System, Solar Backscatter Ultraviolet Spectrometer, and Thematic Mapper.

3. Programs. Funded activities that are approved or are prospective discrete elements of the space budget. Included are: flight programs which use mission and instrument systems to conduct experiments and demonstrate capabilities in space. Examples are the Space Science Platform and the Large Space Structures System Technology and Development Plan. Investigatory programs which are nonflight specific aggregations of activities, often analytic in nature but which may contain flight elements. Examples are 30/20 GHz Wideband Communications satellite program and the National Materials Laboratory. Functional service programs which provide users with space-derived information, capabilities, or methods. An example is the Application Data Service Development program.

In summary, the items presented are the implements which NASA has or envisions to achieve the perceived goals of the civil space program. These goals are expressed in the NASA Five-Year Planning Document, published annually, and this Model serves as a supplement to the current "Five-Year Plan."

The content of the three volumes and their parts has been selected to maintain a clear distinction between different levels of planning information (see Fig. 1). The information in Volume I is for definitive programs, i.e., systems and programs which are approved, planned, or candidates for initiation within the next ten years (see Fig. 2 for definition of these categories). The information contained in Volume III, for systems and programs expected to start after ten years, can be strongly influenced by new technology. Figure 3 shows the relationship



WITHIN TEN-YEAR HORIZON

VOLUME I

System/Program Descriptions and Technology Needs

- Part A: System/Program Summary and Schedule
- Part B: Detailed System/Program Descriptions and Required Technology
- Part C: Technology Requirements Summary

VOLUME II

Space Technology Trends and Forecasts

- Arranged by Disciplines
  - Power and Electric Propulsion
  - Chemical Propulsion
  - Materials and Structures
  - Information Systems
  - Navigation, Guidance and Control
  - Automated Operations

DISTANT HORIZON

VOLUME III

Opportunity Systems/Programs and Technologies

- Part A: Program Office Opportunity Systems and Programs
- Part B: Opportunity Systems and Programs from Other Sources
- Part C: Opportunity Technologies

TECHNOLOGY PLANNING

VOLUME IV

Analysis of Technology Needs and Future Considerations

- Will relate system/program needs to technology development
- Will discuss technology innovations and their potential effects on system and program planning

Figure 1. NASA Space Systems Technology Model

VOLUME I

APPROVED - A

MISSIONS WHICH HAVE BEEN FUNDED AND AUTHORIZED FOR IMPLEMENTATION.

PLANNED - P

MISSIONS DESIGNATED BY THE PROGRAM OFFICES AS POSSIBLE NEW STARTS WITHIN THE NEXT FIVE YEARS.

CANDIDATE - C

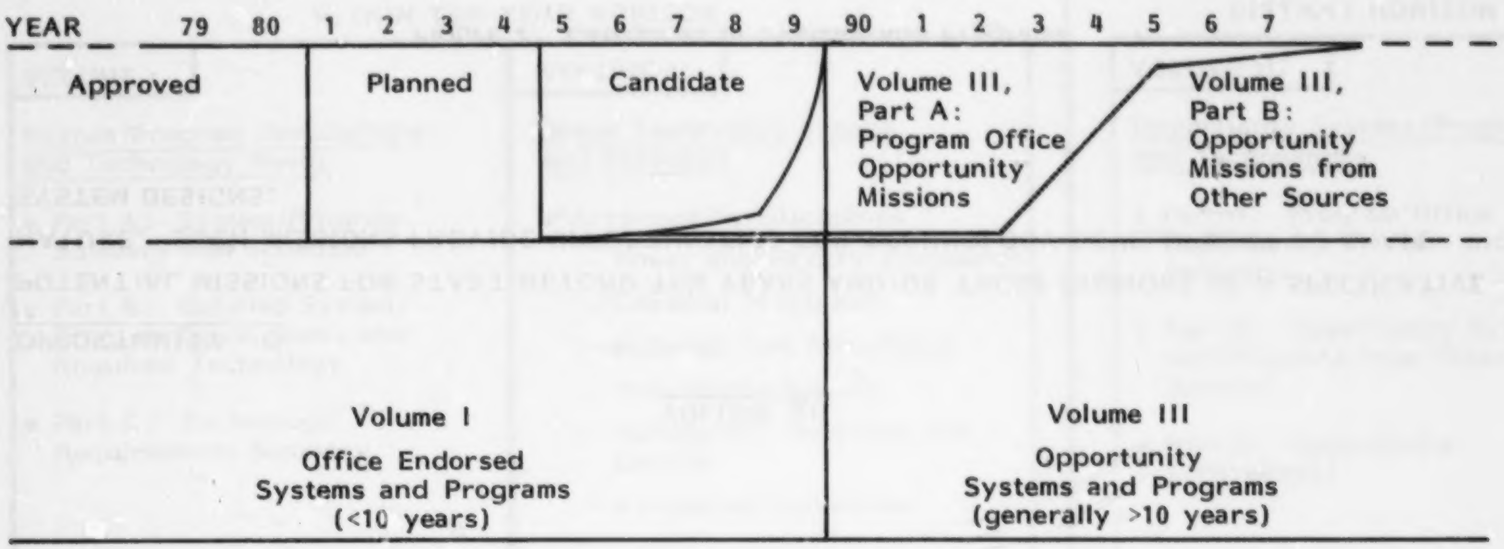
MISSIONS CONSIDERED FOR POSSIBLE INITIATION WITHIN TEN YEARS, BUT CURRENTLY NOT PLANNED AS A NEW START WITHIN THE NEXT FIVE YEARS.

VOLUME III

OPPORTUNITY - O

POTENTIAL MISSIONS FOR START BEYOND TEN YEARS AND/OR THOSE MISSIONS OF A SPECULATIVE NATURE. SUCH MISSIONS PROVIDE OPPORTUNITIES FOR TECHNOLOGY DEVELOPMENT TO SHAPE SYSTEM DESIGNS.

Figure 2. Categories of Systems and Programs


YEAR
79
80
1
2
3
4
5
6
7
8
9
90
1
2
3
4
5
6
7
Approved
Planned
Candidate
Volume III, Part A: Program Office Opportunity Missions
Volume III, Part B: Opportunity Missions from Other Sources
Volume I
Office Endorsed Systems and Programs (<10 years)
Volume III
Opportunity Systems and Programs (generally >10 years)

NOTE: Systems/programs are included in Model if flight or start is 1979 or later.

Figure 3. Model Presentation of NASA Systems and Programs

between the categories, time, and the volumes of this Model. The technology trends and forecast information has been similarly separated into two volumes. Volume II presents data for ongoing and forecastable technology developments. Volume III, Part C presents data on opportunity technologies which have no current credible system or program applications or which cannot be forecasted now.

VOLUME I

Volume I, System/Program Descriptions and Technology Needs, contains details on systems and programs endorsed by the responsible program offices for a start in the next ten years. Identification of the systems and programs and their relative time phasing was obtained from the program offices at NASA Headquarters by means of several iterated reviews over the last six months. Technical characteristics of the systems and programs were compiled to the extent available and subjected to review and validation by the responsible program offices.

The systems and programs are grouped in categories corresponding to basic NASA program areas: Planetary, Astrophysics, Solar Terrestrial, Life Sciences, Resource Observation, Global Environment, Communications, Space Transportation, Utilization of the Space Environment, and Technology Development (OAST instrument systems). They are sequenced by funding and/or development status (Fig. 2). Funded, ongoing systems and programs are designated Approved. Those identifed as possible new starts within the next five years are designated as Planned. Systems and programs identified as new starts within the present five-year plan period but considered for possible initiation within ten years are designated Candidate. Those potentially starting after ten years and/or those of a speculative nature are designated Opportunity; they are presented in Volume III.

Volume I is arranged in three parts:

Part A: System/Program Summary and Schedule

- This is a chronological list of systems and programs by program area (Planetary, Astrophysics, etc.). The list includes system/program name, status, source, start data for major effort, launch data if applicable, and primary contact for information.
- At the end of Part A, the start dates are displayed graphically by program area.

Part B: Detailed System/Program Descriptions and Required Technology

A section for each mission system or program presents technical details.

- The first page presents general information: an illustration; basic features; and narrative on objective, description, technology needs, references, and contacts.
- Following pages present technical characteristics to the extent that they are now known or relevant. A technical characteristic is generally presented as a nominal value, the degree of confidence in the value, and the state of technology readiness. Comments are provided to explain particular conditions.
- Instrument systems are presented in a format which contains name, status, carrier, physical and general properties, principal purpose and features, principal physical property measured, associated ranges and resolutions, comments, sources, and contacts. For the science programs (Planetary, Astrophysics, Solar Terrestrial, and Life Sciences) the instrument systems are not presented separately, but are grouped on a sheet with the related mission system.

Part C: Technology Requirements Summary

- Values of particular technical characteristics are tabulated for all mission systems. The data are further presented versus time. Analysis of the plotted data should reveal trends in technology demanded by the aggregate of NASA mission systems and programs envisioned for the next ten years. In Volume III, Part A, the characteristics of mission systems and programs beyond ten years are added to these plots.

VOLUME II

Volume II, Space Technology Trends and Forecasts, presents data characterizing space technology developments. The present and projected status of space technology is arranged by discipline: power and electric propulsion; chemical propulsion; materials and structures, information systems; navigation, guidance and control; and automated operations. Past technology trends, state of the art, and a ten-year or more forecast of capabilities are included.

These forecasts were obtained from NASA technology development managers at Headquarters and the Centers. The technology development managers were asked to identify figures of merit for technology discipline and forecast their growth. The resulting set of forecasts in Volume II can be related in many cases to Volumes I and III system and program characteristics.

VOLUME III

Volume III, Opportunity Systems/Programs and Technologies, is divided into three parts:

- Part A: Program Office Opportunity Systems and Programs, presents technical details on systems and programs which the offices endorse but which are speculative or beyond ten years. The format is identical to Volume I, Parts B and C. These missions are called "opportunity" because there is ample time for vigorous technology development to greatly impact their form and feasibility.
- Part B: Opportunity Systems and Programs from Other Sources, presents a selection of systems and programs which cannot now be advocated by the NASA program offices for various reasons; they are too distant, too speculative in feasibility, pertinence, or utility; or too controversial.
- Part C: Opportunity Technologies, presents information on emerging technologies. Opportunity technology often provides revolutionary advances which may enable otherwise unachievable mission systems. The format is a one-page description of contacts, character, relation to mission and instrument systems and other technologies, status descriptors, and coarse forecasts.

VOLUME IV

(to be supplied at a later date)

Volume IV, Analysis of Technology Needs and Future Considerations, was to relate system and program needs to technology development and discuss technology innovations and their potential effects on mission and program planning. As of the date of this issue, Volume IV has not been produced. NASA Headquarters, supported by the Centers, is preparing technology development plans which would form the essence of this volume. Drafts of Volumes I, II, and III of the Model served as the primary basis for preparing these plans. Further evolution will lead to a presentation of technology plans in a formal Volume IV.

MODEL USE AND MAINTENANCE

The NASA Space Systems Technology Model is an outcome of the space technology program planning and implementation process. The Model is intended to be a companion to the NASA Five-Year Planning Document and will be updated annually. It is believed that the Model will improve steadily through subsequent iterations.

Requests for additional copies of the Model should be addressed to Stan Sadin, Code RS-5, NASA Headquarters, Washington, DC 20546. Comments and suggestions for additional information to be included in future updates should be sent to the same address.

ACKNOWLEDGMENTS

This Model is the product of support from many organizations and individuals. An acknowledgment of the contributors appears at the end of this volume.

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PART A: SYSTEM/PROGRAM SUMMARY AND SCHEDULE

SYSTEM/PROGRAM LIST

The following pages contain listings of all systems and programs that were validated by NASA Headquarters program offices for inclusion in this edition of the Model.

Within each basic NASA program cateogry (Planetary, Astrophysics, etc.) mission systems/programs are arranged according to their status: approved (A), planned (P), candidate (C), or opportunity (O). Each subgroup is further ordered chronologically by start date. A reference number, source, state date, launch date, name of the responsible program office, and the designated contact are also included in this tabulation. Instrument systems are similarly arranged within each basic NASA program category.

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Planetary

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
P-1	Galileo	A	NASA 80-84 Plan	Ongoing	1985	OSS	J. Casani, JPL J. Givens, ARC
P-2	Venus Orbiting Imaging Radar	P	NASA 80-84 Plan	1982	1986	OSS	S. Dallas, JPL
P-3	International Comet Mission	P	NASA 80-84 Plan	1982	1985	OSS	K. Atkins, JPL
P-4	Saturn Orbiter Dual Probe	P	NASA 80-84 Plan OSS 81-85 Plan	1984	1989	OSS	D. Pivirotto, JPL
P-5	Mars Advanced Technology (Sample Return)	P	NASA 80-84 Plan OSS 81-85 Plan	1984	1994 1996	OSS	J. French, JPL
P-6	Uranus, Neptune, Pluto Program	C	OSS 81-85 Plan	1986	1990 1991 1992 1994	OSS	J. Niehoff, SAI R. Wallace, JPL
P-7	Asteroid Multiple Rendezvous	O	NASA 80-84 Plan OSS 81-85 Plan	>1990	ND	OSS	R. Boain, JPL
P-8	Lunar Polar Orbiter	O	OSS 81-85 Plan	>1990	ND	OSS	J. Burke, JPL
P-9	Mercury Orbiter and Lander	O	NASA 80-84 Plan OSS 81-85 Plan	>1990	ND	OSS	C. Uphoff, JPL
P-10	Comet Sample Return	O	NASA 80-84 Plan OSS 81-85 Plan	>1990	ND	OSS	W. Wells, SAI
P-11	Near Earth Asteroid Sample Return	O	NASA 80-84 Plan OSS 81-85 Plan	>1990	ND	OSS	W. Wells, SAI
P-12	Venus Lander	O	NASA 80-84 Plan OSS 81-85 Plan	>1990	ND	OSS	J. Murphy, ARC

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Planetary (Cont.)

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
P-13	Automated Mobile Lunar Surface Survey	0	OSS letter on Model (M-12) August 1979	>1990	ND	OSS	J. French, JPL
P-14	Automated Planetary Station	0	OSS letter on Model (M-12) August 1979	>1990	ND	OSS	W. Wells, SAI
P-15	Lunar Backside Lander and Sample Return	0	OSS 81-85 Plan	>1990	ND	OSS	P. Roberts, JPL
P-16	Ganymede Lander	0	OSS letter on Model (M-12) August 1979	>1990	ND	OSS	R. Boain, JPL

NASA SPACE SYSTEMS TECHNOLOGY MODEL
MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Astrophysics

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
A-i	High Energy Astronomy Observatory-C	A	NASA 80-84 Plan	Ongoing	1979	OSS	F. Speer, MSFC
A-2	Infrared Astronomical Satellite (IRAS)	A	NASA 80-84 Plan	Ongoing	1981	OSS	H. Aumann, JPL
A-3	Space Telescope	A	NASA 80-84 Plan	Ongoing	1983	OSS	F. Speer, MSFC C. O'Dell, MSFC
A-4	Cosmic Background Explorer (COBE)	A	NASA 80-84 Plan	1980	1984	OSS	J. Mather, GSFC S. Paddack, GSFC
A-5	Extreme Ultraviolet Explorer	P	NASA 80-84 Plan	1981	1985	OSS	S. Willis, MSFC
A-6	Shuttle Infrared Telescope Facility (SIRTF)	P	NASA 80-84 Plan	1981	1985	OSS	L. Young, ARC
A-7	Gamma Ray Observatory (GRO)	P	NASA 80-84 Plan	1981	1985	OSS	D. Kniffen, GSFC
A-8	Gravity Probe B (GP-B)	P	NASA 80-84 Plan	1982	1985	OSS	R. Potter, MSFC
A-9	Advanced X-Ray Astrophysics Facility	P	NASA 80-84 Plan	1983	1987	OSS	M. Weisskopf, MSFC
A-10	X-Ray Timing Explorer	P	OSS 81-85 Plan	1983	1986	OSS	W. Hibbard, GSFC
A-11	Starlab	P	NASA 80-84 Plan	~1984	~1987	OSS	T. Stecher, GSFC
A-12	X-Ray Observatory	C	NASA 80-84 Plan	<1990	ND	OSS	E. Boldt, GSFC
A-13	Cosmic Ray Observatory	C	NASA 80-84 Plan	<1990	ND	OSS	J. Ormes, GSFC
A-14	Large Area Modular Array of Reflectors (LAMAR)	C	NASA 80-84 Plan	<1990	ND	OSS	E. Mercanti, GSFC

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Astrophysics (Cont.)

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
A-15	Very Long Base-Line Radio Interferometer	C	NASA 80-84 Plan 30-m Diameter	<1990	ND	OSS	R. Preston, JPL
A-16	Orbiting Submillimeter Telescope	C	OSS 81-85 Plan				
A-17	Large Ambient Deployable IR Telescope	C	OSS 81-85 Plan	1985-90	ND	OSS	P. Swanson, JPL
A-18	Infrared Interferometer	O	OSS letter on Model (M-12) August 1979	1985-90	ND	OSS	J. Murphy, ARC
A-19	Gravity Wave Interferometer	O	OSS letter on Model (M-12) August 1979	>1990	ND	OSS	J. Murphy, ARC
A-20	Coherent Optical System of Modular Imaging Collectors (COSMIC)	O	>20-m base line; OSS letter on Model (M-12) August 1979	>1990	ND	OSS	J. Rosendhal, SC-7
A-21	Large Optical/UV Telescope, Diffraction Limited	O	OSS letter on Model (M-12) August 1979	>1990	ND	OSS	M. Nein, MSFC
A-22	100-Meter Thinned Aperture Telescope	O	OSS letter on Model (M-32) February 1980 ~100-m	>1990	ND	OSS	J. Warner, MSFC
				>1990	ND	OSS	J. Warner, MSFC

NASA SPACE SYSTEMS TECHNOLOGY MODEL
MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Solar Terrestrial

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
S-1	Solar Maximum Mission	A	NASA 80-84 Plan	Ongoing	1980	OSS	P. Burr, GSFC
S-2	Dynamics Explorer	A	NASA 80-84 Plan	Ongoing	1981	OSS	G. Hogan, GSFC
S-3	International Solar Polar Mission	A	NASA 80-84 Plan	Ongoing	1983	OSS	W. Purdy, JPL J. Slonski, JPL
S-4	Solar Optical Telescope (SOT)	A	NASA 80-84 Plan	1980	1984	OSS	E. Schmidt, GSFC
S-5	Chemical Release Module Facility	A	NASA 80-84 Plan	1980	1983	OSS	L. Richards, MSFC
S-6	Active Magnetospheric Particle Tracer Experiment	P	NASA 80-84 Plan	1981	1983	OSS	G. Ousley, GSFC
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	P	NASA 80-84 Plan	1981	1985 1986	OSS	J. Longanecker, GSFC
S-8	Solar Soft X-Ray Telescope	P	OSS 81-85 Plan (Shuttle/Spacelab)	1982	1987	OSS	G. Stouffer, GSFC C. Stout, GSFC
S-9	Subsatellite Facility	P	NASA 80-84 Plan	1983	1986	OSS	R. Benson, GSFC
S-10	Plasma Turbulence Explorer	P	OSS 81-85 Plan	1983	ND	OSS	R. Wallace, JPL
S-11	Solar Probe	P	NASA 80-84 Plan	1984	1987	OSS	J. Randolph, JPL
S-12	Solar Terrestrial Observatory	C	NASA 80-84 Plan	1985	1989	OSS	R. Chappell, MSFC
S-13	Solar Cycle and Dynamics Mission	C	OSS letter on Model (M-12) August 1979	1986	ND	OSS	D. Suddeth, GSFC

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Solar Terrestrial (Cont.)

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
S-14	Pinhole Satellite	0	NASA 80-84 Plan	>1984	ND	OSS	J. Dabbs, MSFC
S-15	Close Solar Orbiter	0	OSS 81-85 Plan	>1990	ND	OSS	R. Wallace, JPL

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Life Sciences

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
L-1	Spacelab Biological Experiments	A	NASA 80-84 Plan (Shuttle, Spacelab 4)	Ongoing	1982	OSS	M. Sander, SB-3
L-2	Space Science Platform	P	NASA 80-84 Plan Long Duration Experiment	1982	1987	OSS	M. Sander, SB-3
L-3	Search for Extraterrestrial Intelligence (SETI)	O		TBD	TBD	OSS	M. Sander, SB-3

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Resource Observation

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
R-1	Magsat	A	NASA 80-84 Plan	Ongoing	1979	OSTA	J. Murphy, ERG-2
R-2	Landsat D	A	NASA 80-84 Plan	Ongoing	1982	OSTA	H. Mannheimer, ERL-2
R-3	Crustal Dynamics Program	A	OSTA 81-85 Plan	Ongoing	NA	OSTA	T. Fichetti, ERG-2
R-4	Gravsat A	P	NASA 80-84 Plan	1982	1985	OSTA	T. Fichetti, ERG-2
R-5	Operational Earth Resources System	P	OSTA 81-85 Plan	1983	1988-1990	OSTA	W. Piotrowski, ER-2
R-6	Advanced Thermal Mapping Applications Satellite	P	NASA 80-84 Plan	1984	1988	OSTA	W. Piotrowski, ER-2
R-7	Magnetic Field Survey B	P	NASA 80-84 Plan	1985	1988	OSTA	T. Fichetti, ERG-2
R-8	Soil Moisture Research and Assessment	C	NASA 80-84 Plan	Mid 1980s	Late 1980s	OSTA	M. Calabrese, ERL-2

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Resource Observation

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
RI-1	Vector and Scalar Magnetometers	A	Magsat	Ongoing	1979	OSTA	J. Murphy, ERG-2
RI-2	Multispectral Scanner	A	Landsat D	Ongoing	1982	OSTA	H. Mannheimer, ERL-2
RI-3	Thematic Mapper	A	Landsat D, OERS	Ongoing	1982	OSTA	H. Mannheimer, ERL-2
RI-4	Shuttle Multispectral Infrared Radiometer	A	NASA 80-84 Plan/STS-2	Ongoing	1981	OSTA	B. B. Schardt, ERS-2
RI-5	Large Format Camera	A	NASA 80-84 Plan/STS-1W	Ongoing	1984	OSTA	D. P. Rogers, ERS-2
RI-6	SIR-A	A	NASA 80-84 Plan/STS-2	Ongoing	1981	OSTA	C. Elachi, JPL
RI-7	Multispectral Linear Array	P	ER/Candidate for OERS	1982	1985	OSTA	W. Piotrowski, ER-2
RI-8	Range Rate Measuring Devices	P	Gravsat A	1982	1985	OSTA	T. Fichetti, ERG-2
RI-9	Time and Frequency Transfer Experiment	P	NASA 80-84 Plan	1982	1985	OSTA	R. Decher, MSFC
RI-10	Gravity Gradiometer	P	NASA 80-84 Plan	1982	1985	OSTA	M. Page, MSFC
RI-11	Multispectral Mid-IR Imager	P	NASA 80-84 Plan	1983	1986	OSTA	A. Goetz, JPL
RI-12	Passive Microwave Radiometer	P	Soil Moisture Research and Assessment	Mid 1980s	Late 1980s	OSTA	M. Calabrese, ERL-2
RI-13	Active Microwave Sensor	P	Soil Moisture Research and Assessment	Mid 1980s	Late 1980s	OSTA	M. Calabrese, ERL-2
RI-14	Thermal IR Sensor	P	Soil Moisture Research and Assessment	Mid 1980s	Late 1980s	OSTA	M. Calabrese, ERL-2

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Resource Observation (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
RI-15	Visible IR Sensor	P	Soil Moisture Research and Assessment	Mid 1980s	Late 1980s	OSTA	M. Calabrese, ERL-2
RI-16	Earth Resources Synthetic Aperture Radar	P	NASA 80-84 Plan	1984	1988	OSTA	B. Schardt, ERS-2
RI-17	Nd:YAG Spaceborne Laser System	O	Recently deleted from near term plans	ND	ND	OSTA	T. Fichetti, ERG-2

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Global Environment

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
E-1	Stratospheric Aerosol and Gas Experiment	A	NASA 80-84 Plan	Ongoing	1979	OSTA	D. Diller, EB-8
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)	A	NASA 80-84 Plan	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8
E-3	Solar Mesosphere Explorer (SME)	A	NASA 80-84 Plan	Ongoing	1981	OSTA	S. Tilford, EBT-8
E-4	Earth Radiation Budget Satellite	A	NASA 80-84 Plan	Ongoing	1982	OSTA	D. Diller, EB-8
E-5	NOAA A-G/TIROS-N	A	NASA 80-84 Plan	Ongoing	1979	OSTA	A. J. Cervenka, EB-8
E-6	National Oceanic Satellite System (NOSS)	P	NASA 80-84 Plan	1981	1986-1987	OSTA	D. Broome, EB-8
E-7	Upper Atmospheric Research Satellite (UARS)	P	NASA 80-84 Plan	1982	1985-1986	OSTA	R. Seals, EBT-8
E-8	NOSS Research Program	P	OSTA 81-85 Plan	1982	1985	OSTA	R. Schiffer EB-8
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)	P	NASA 80-84 Plan	1983	1986-1987	OSTA	S. Wilson, EBC-8
E-10	Operational Meteorology Satellite System	P	NASA 80-84 Plan	Mid 1980s	Late 1980s	OSTA	W. Bishop, EB-8
E-11	Ocean Research (SAR)	C	OSTA 81-85 Plan	1985	1989	OSTA	S. Wilson, EBC-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-1	4-Channel Spectral Radiometer	A	Stratospheric Aerosol and Gas Experiment (SAGE)	Ongoing	1979	OSTA	D. Diller, EB-8
EI-2	Gas Filter Correlation Infrared Analyzer	A	Measurement of Air Pollution from Shuttle/SL-3	Ongoing	1983	OSTA	E. Prior, EBT-8
EI-3	Earth Radiation Budget Experiment	A	Earth Radiation Budget Satellite (ERBS)	Ongoing	1982	OSTA	D. Diller, EB-8
EI-4	Stratospheric Aerosol and Gas Experiment II	A	ERBS, 7-channel instrument	Ongoing	1982	OSTA	D. Diller, EB-8
EI-5	Halogen Occultation Experiment	A	ERBS, SL-3	Ongoing	1982	OSTA	R. Arnold, EB-8
EI-6	Atmospheric Trace Molecule Spectroscopy	A	SL-3	Ongoing	1983	OSTA	L. Simmons, JPL
EI-7	Nighttime/Daytime Optical Survey of Lightning and Convective Phenomena Experiment (NOSL)	A	Early Shuttle flight	Ongoing	1982	OSTA	J. Dodge, EBT-8
EI-8	Active Cavity Radiometer (ACR)	A	OSTA 81-85 Plan/SL-1	Ongoing	1982	OSTA	R. Wilson, JPL
EI-9	Space Environment Monitoring System (SEM)	A	OSTA 81-85 Plan	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8
EI-10	VISSR Atmospheric Sounder (VAS)	A	OSTA 81-85 Plan/GOES D,E,F	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-11	High Resolution Infrared Radiation Sounder (HIRS)	A	OSTA 81-85 Plan/ NOAA A-G	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8
EI-12	Microwave Sounding Unit (MSU)	A	OSTA 81-85 Plan/ NOAA A-G	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8
EI-13	Stratospheric Sounding Unit (SSU)	A	OSTA 81-85 Plan/ NOAA A-G	Ongoing	1979 on	OSTA	A. J. Cervenka, EB-8
EI-14	Solar Backscatter Ultraviolet Spectrometer (SBUV)	A	OSTA 81-85 Plan/ NOAA F-G	Ongoing	1984-1985	OSTA	J. Lehman, EBC-8 R. Seals, EBT-8
EI-15	Ultraviolet Ozone Experiment	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-16	1.27 μm Airglow Sensor	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-17	Visible NO_2 Experiment	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-18	4-Channel Infrared Sensor	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-19	Solar Ultraviolet Monitor	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-20	Proton Alarm	A	Solar Mesosphere Explorer	Ongoing	1981	OSTA	S. Tilford, EBT-8
EI-21	Vertical Temperature Profile Radiometer	A	NOAA-A	Ongoing	1979	OSTA	A. McCulloch, GSFC

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-22	Advanced Very High Resolution Radiometer (AVHRR)	A	OSTA 81-85 Plan/TIROS N/NOAA A-G	Ongoing	1979	OSTA	A. J. Cervenka, EB-8
EI-23	Dual Frequency Scatterometer	P	OSTA 81-85 Plan/ Spacelab	Early 1980s	Mid 1980s	OSTA	W. Townsend, EBC-8 J. Johnson, LaRC
EI-24	Dual Antenna Multibeam Altimeter	P	OSTA 81-85 Plan/ Spacelab	Early 1980s	Mid 1980s	OSTA	W. Townsend, EBC-8
EI-25	Large Antenna Multifrequency Microwave Radiometer (LAMMR)	P	National Oceanic Satellite System (NOSS)	1981	1986	OSTA	D. Broome, EBC-8
EI-26	Scatterometer (SCAT)	P	National Oceanic Satellite System (NOSS)	1981	1986-1987	OSTA	D. Broome, EBC-8
EI-27	Scanning Multichannel Microwave Radiometer	P	OSTA Plans	1981	1986-1987	OSTA	D. Broome, EBC-8
EI-28	Radar Altimeter (ALT)	P	NOSS	1981	1986-1987	OSTA	W. Townsend, EBC-8
EI-29	Coastal Zone Color Scanner	P	NOSS	1981	1986-1987	OSTA	D. Broome, EBC-8
EI-30	Solar UV Spectrometer	P	Upper Atmospheric Research Satellite (UARS), SL-2	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-31	Doppler Interferometer	P	UARS/Spacelab	1982	1985-1986	OSTA	R. Seals, EBT-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-32	Modulated Gas Cell Radiometer	P	UARS	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-33	Filter Radiometer	P	UARS/SME	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-34	Nadir Emission Radiometer	P	UARS	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-35	Emission Radiometer	P	UARS	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-36	Occultation Radiometer	P	UARS	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-37	UV Airglow Emission Spectrometer	P	UARS/SL-1	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-38	1.27-µm Emission Spectrometer	P	UARS/SME	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-39	Far IR Spectrometer	P	UARS	1982	1985-1986	OSTA	R. Seals, EBT-8
EI-40	Laser Heterodyne Radiometer	P	UARS	1982	1985-1986	OSTA/OAST	R. Seals, EBT-8 J. Lundholm, RSI
EI-41	Microwave Limb Sounder	P	UARS/Shuttle	1982	1985-1986	OSTA/OAST	R. Seals, EBT-8 J. Lundholm, RSI
EI-42	Lidar	P	Multiuse Lidar System, Spacelab	1983	1987	OSTA	R. Seals, EBT-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-43	Radar Altimeter	P	Ocean Circulation Mission--Topographical Experiment (TOPEX)	1983	1986	OSTA	W. Townsend, EBC-8
EI-44	2-Channel Microwave Radiometer	P	TOPEX	1983	1986	OSTA	W. Townsend, EBC-8
EI-45	Cryogenic Limb-Scanning Interferometer Radiometer (CLIR)	P	NASA 83-84 Plan	1984	Late 1980s	OSTA	R. Seals, EBT-8
EI-46	Spaceborne Meteorological Radar	P	OSTA Plans	<1985	ND	OSTA	S. Tilford, EBT-8
EI-47	Lidar Pressure and Temperature Sensor	P	OSTA Plans	<1985	ND	OSTA	J. Theon, EBC-8
EI-48	Microwave Pressure Sounder	P	OSTA Plans	<1985	ND	OSTA	D. Flowers, JPL J. Theon, EBC-8
EI-49	Standard Ozone Sounding Unit	P	OSTA Plans	<1985	ND	OSTA	R. J. Pinamonti, GSFC R. Seals, EBT-8
EI-50	Laser Absorption Spectrometer	P	OSTA Plans	<1985	ND	OSTA	R. Manzies, JPL R. Seals, EBT-8
EI-51	Correlation Interferometry for Measurement of Atmospheric Trace Species	P	OSTA Plans	<1985	ND	OSTA	P. Lebel, LaRC E. Prior, EBT-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-52	Temperature Humidity Infrared Radiometer	P	OSTA Plans	<1985	ND	OSTA	T. Anderson, GSFC
EI-53	Atmospheric Emission Photometric Imaging (AEPI)	P	OSTA Plans	<1985	ND	OSTA	R. Seals, EBT-8
EI-54	Advanced Meteorological Sounding Unit	P	OSTA Plans	<1985	ND	OSTA	J. Theon, EBC-8
EI-55	Advanced Meteorological Temperature Sounder	P	OSTA Plans	<1985	ND	OSTA	J. Theon, EBC-8
EI-56	High Resolution Doppler Imager	P	OSTA Plans	<1985	ND	OSTA	R. Arnold, EB-8
EI-57	High Resolution Solar Spectrometer	P	OSTA Plans/Spacelab	<1985	ND	OSTA	R. Arnold, EB-8
EI-58	Atmosphere General Circulation Experiment	P	OSTA Plans/Spacelab	<1985	ND	OSTA	J. Theon, EBC-8
EI-59	Lightning Mapper	P	OSTA Plans	<1985	ND	OSTA	J. Dodge, EBT-8
EI-60	Cloud Radiation Experiment	P	OSTA Plans	<1985	ND	OSTA	R. Schiffer, EB-8
EI-61	Doppler Geostationary Imager	P	OSTA Plans	<1985	ND	OSTA	J. Theon, EBC-8
EI-62	Salinity Radiometer	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Global Environment (Cont.)

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
EI-63	Ice Sounder	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8
EI-64	Local Wave Spectra Sensor	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8
EI-65	Laser Altimeter	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8
EI-66	Ocean Synthetic Aperture Radar	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8
EI-67	Pushbroom Radiometer	P	OSTA Plans	<1985	ND	OSTA	W. Townsend, EBC-8
EI-68	Atmospheric Cloud Physics Laboratory	O	Recently deleted from near term plans	ND	ND	OSTA	J. Dodge, EBT-8 R. Arnold, EB-8

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Communications

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
C-1	Tracking and Data Relay Satellite System (TDRSS)	A	NASA 80-84 Plan	Ongoing	1981	OSTDS	R. Aller, TX-1
C-2	Search and Rescue Mission	A	NASA 80-84 Plan	Ongoing	1982	OSTA	T. McGunigal, EC
C-3	Application Data Service Development	A	NASA 80-84 Plan	Ongoing	NA	OSTA	J. Heuser, ESI
C-4	30/20 GHz Wideband Communications Satellite Program	P	OSTA 81-85 Plan	1982	1986	OSTA	J. McElroy, EC-4
C-5	Geostationary Platform Demonstration	P	OSTS 81085 Plan	1983	1990	OSTS	M. Nolan, MTC-3
C-6	Multi-Service Thin Route Narrowband Program	O	OSTA 81-85 Plan	1984	1988	OSTA	G. Knouse, ECE-4
C-7	Tracking and Data Relay Satellite System (TDRSS-II)	O	OSTDS letter on Model (M-34) March 1980	1986	1991	OSTDS	R. Aller, TX-1
C-8	Orbiting Deep Space Relay Station	O	NASA 80-84 Plan	>1990	>1990	OSTDS	H. Fosque, TS-1 J. Hunter, JPL

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Space Transportation

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
T-1	Scout	A	NASA 80-84 Plan	Ongoing		OSTS	P. Goozh, OLE
T-2	Delta 3914	A	NASA 80-84 Plan	Ongoing		OSTS	P. Eaton, OLE
T-3	Atlas-F	A	NASA 80-84 Plan	Ongoing		OSTS	J. Salmanson, OLE
T-4	Atlas/Centaur	A	NASA 80-84 Plan	Ongoing		OSTS	F. Schmidt, OLE
T-5	Space Shuttle	A	NASA 80-84 Plan	Ongoing	1980	OSTS	H. Roseman, MSH-7
T-6	Spinning Solid Upper State (SSUS)	A	NASA 80-84 Plan	Ongoing	1981	OSTS	M. Kitchens, MXS
T-7	Multimission Modular Spacecraft	A	NASA 80-84 Plan	Ongoing	1980 on	OSS	M. McDonald, ST-5
T-8	Inertial Upper Stage (IUS)	A	NASA 80-84 Plan	Ongoing	1982	OSTS	B. Lam, MXS
T-9	Solar Electric Propulsion	P	OSTS 81-85 Plan	1981	1985	OSTS	W. Kisko, MTG-3
T-10	Orbital Transfer Vehicle	P	OSTS 81-85 Plan	1983	1990	OSTS	L. Edwards, MTC-3
T-11	Teleoperator Maneuvering System	C	OSTS 81-85 Plan	1982	ND	OSTS	W. Smith, MTG-3
T-12	Manned GEO Sortie	C	NASA 80-84 Plan	1986	1992	OSTS	L. Edwards, MTC-3

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Space Transportation (Cont.)

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
T-13	Heavy-Lift Launch Vehicle	0	NASA 80-84 Plan	ND	ND	OSTS	L. Edwards, MTC-3
T-14	Advanced Electric Propulsion	0	NASA 80-84 Plan	1990	ND	OSTS	W. Kisko, MTG-3
T-15	Unconventional Orbital Transfer Vehicle	0	OSTS letter on Model (M-16) August 1979	1990	ND	OSTS	L. Edwards, MTC-3

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Utilization of the Space Environment

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
U-1	National Materials Laboratory	A	OSTA 81-85 Plan	Ongoing	Ongoing	OSTA	J. Carruthers, EM-7
U-2	Spacelab	A	NASA 80-84 Plan	Ongoing	1982	OSTS	E. James, MSF-5
U-3	Extraterrestrial Materials Processing	A	OSTA 81-85 Plan	Ongoing	NA	OSTA	J. Carruthers, EM-7
U-4	Tethered Satellite System	P	OSTS 81-85 Plan (includes OSTA magnetometer)	1981	1983	OSTS	E. Brazill, MTC-3
U-5	Large Space Structures System Technology and Development Program	P	OSTS 81-85 Plan	1981	1984	OSTS	I. Bekey, MTC-3
U-6	Power Extension Package	P	OSTS 81-85 Plan	1981	1983	OSTS	W. Smith, MTG-3
U-7	Science and Applications Space Platform	P	OSTS 81-85 Plan	1982	1985	OSTS	T. Hagler, MTG-3
U-8	25-kW Power System	P	NASA 80-84 Plan	1983	1986	OSTS	W. Smith, MTG-3
U-9	Materials Experiment Carrier	P	OSTS 81-85 Plan (Shuttle and Power Module)	1983	1986	OSTS	M. Nolan, MTC-3 J. Carruthers, EM-7
U-10	Materials Experiment Carrier II	P	OSTS 81-85 Plan	1986	1989	OSTS	M. Nolan, MTC-3 J. Carruthers, EM-7
U-11	Large Power Module	P	NASA 80-84 Plan (200-500 kW)	1990	ND	OSTS	W. Kisko, MTG-3

NASA SPACE SYSTEMS TECHNOLOGY MODEL

MISSION SYSTEM AND PROGRAM LIST

CATEGORY: Utilization of the Space Environment (Cont.)

NO.	MISSION NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
U-12	Materials Experimentation Module	O	OSTS 81-85 Plan	1990	ND	OSTS	M. Nolan, MTC-3 J. Carruthers, EM-7
U-13	Space Power Technology Demonstration	O	OSTS 81-85 Plan	1990	ND	OSTS	W. Kisko, MTG-3
U-14	Space Operational Center (SOC)	O	OSTA 81-85 Plan	ND	ND	OSTS	R. Frietag, MTG-3

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: Utilization of the Space Environment

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
UI-1	Instrument Pointing System	A	NASA 81-85 Plan	Ongoing	ND	OSS	R. Kennedy, SM-8
UI-2	AGS Pointing System	A	NASA 81-85 Plan	Ongoing	ND	OSS	R. Kennedy, SM-8
UI-3	Fluid Experiment System	A	OSTA 81-85 Plan/SL-3	Ongoing	1983	OSTA	J. Carruthers, EM-7
UI-4	Gradiometer	P	OSTA 81-85 Plan, Tethered Satellite	1982	1983	OSTA	M. Page, MSFC
UI-5	Solidification Experiment System	P	OSTA 81-85 Plan	1982	1984	OSTA	J. Carruthers, EM-7
UI-6	High Gradient Furnace System	P	OSTA 81-85 Plan	1982	1984	OSTA	J. Carruthers, EM-7
UI-7	Acoustic Containerless Processing Module	P	OSTA 81-85 Plan	1982	1984	OSTA	J. Carruthers, EM-7
UI-8	Electromagnetic Containerless Processing System	P	OSTA 81-85 Plan	1982	1984	OSTA	J. Carruthers, EM-7
UI-9	Isoelectric Focusing System	P	OSTA 81-85 Plan	1982	1984	OSTA	J. Carruthers, EM-7
UI-10	Biological Processing System	P	OSTA 81-85 Plan	1983	1985-1986	OSTA	J. Carruthers, EM-7
UI-11	Analytical Floating Zone System	P	OSTA 81-85 Plan	<1985	ND	OSTA	J. Carruthers, EM-7
UI-12	Space Vacuum Research Demonstration	P	OSTA 81-85 Plan	1984	ND	OSTA	J. Carruthers, EM-7

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: OAST

NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
OI-1	Feature Identification and Landmark Experiment	A	NASA 81-85 Plan	Ongoing	1981	OAST	J. Lundholm, RSI
OI-2	Induced Environment Contamination Monitor	A	OAST 81-85 Plan/all Shuttle test flights	Ongoing	1980	OAST	R. Gualdoni, RSS
OI-3	Drop Dynamics Module	A	NASA 81-85 Plan/SL-3	Ongoing	1983	OAST	J. Lundholm, RSI
OI-4	Solar Cell Calibration Facility	A	NASA 81-85 Plan/STS-6	Ongoing	1982	OAST	R. Gualdoni, RSS
OI-5	Tribology	A	NASA 81-85 Plan/STS-9	Ongoing	1982	OAST	R. Gualdoni, RSS
OI-6	Miniature Electrostatic Accelerometer (MESA)	A	NASA 81-85 Plan/STS-16	Ongoing	1983	OAST	R. Gualdoni, RSS
OI-7	Super Fluid Helium Experiment	A	NASA 81-85 Plan/STS-16	Ongoing	1983	OAST	J. Lundholm, RSI
OI-8	Thermal Canister	A	NASA 81-85 Plan/STS-4	Ongoing	1981	OAST	R. Gualdoni, RSS
OI-9	Infrared Materials	A	NASA 81-85 Plan/STS-20	Ongoing	1983	OAST	J. Lundholm, RSI
OI-10	Long Duration Exposure Facility	A	NASA 81-85 Plan/STS-12	Ongoing	1982	OAST	R. Gualdoni, RSS
OI-11	8-cm Ion Engine Demonstration	A	NASA 81-85 Plan/P80-1	Ongoing	1981	OAST	R. Gualdoni, RSS
OI-12	SEP Solar Array Shuttle Flight	A	NASA 81-85 Plan/STS-10	Ongoing	1982	OAST	J. DiBattista, RSS
OI-13	ASPS Vernier System	A	OAST 81-85 Plan	Ongoing	ND	OAST	J. Lundholm, RSI

NASA SPACE SYSTEMS TECHNOLOGY MODEL

INSTRUMENT LIST

CATEGORY: OAST (Cont.)

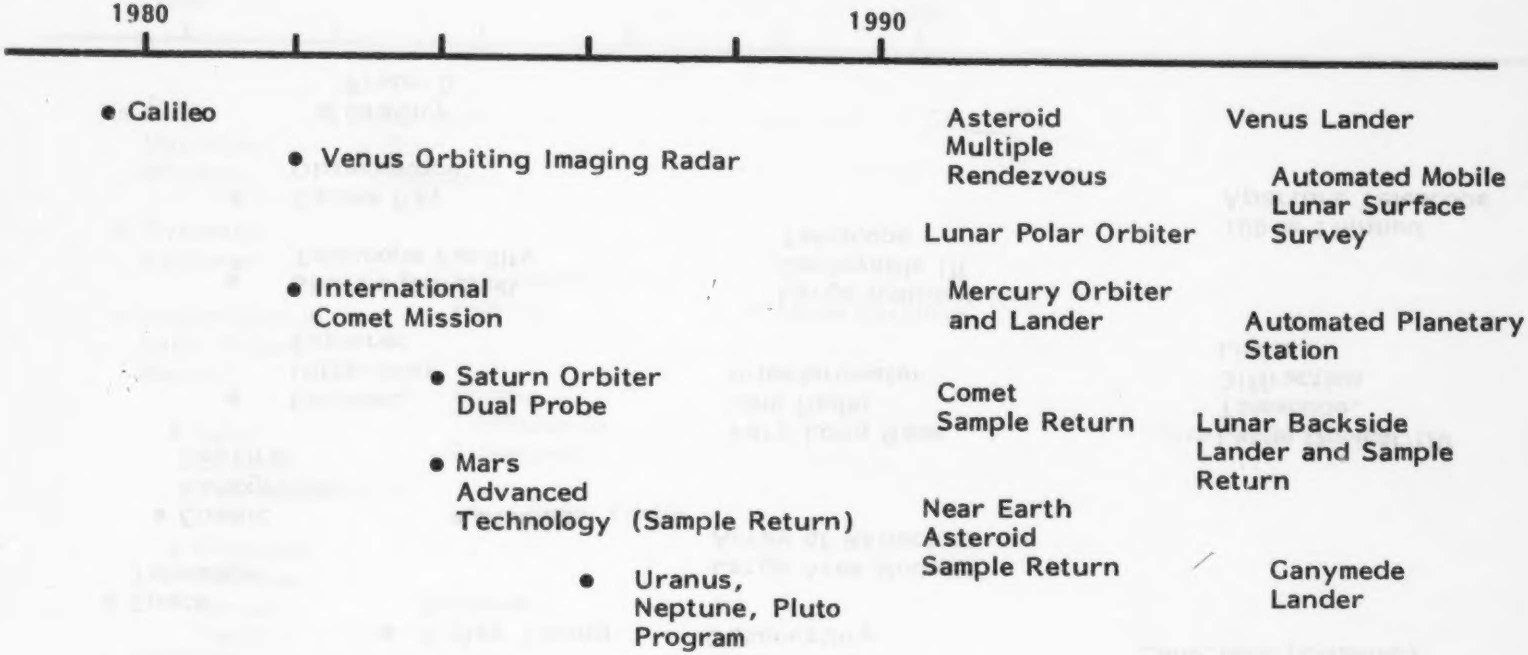
NO.	INSTRUMENT NAME	STATUS	SOURCE/COMMENTS	START DATE	LAUNCH DATE	OFFICE	CONTACT
OI-14	Propulsion Contamination Effects Module	P	OAST/RS	1983	1985	OAST	R. Gualdoni, RSS
OI-15	Zero Gravity Combustion Facility	O	OAST 81-85 Plan	ND	ND	OAST	J. Lundholm, RSI
OI-16	Two-Phase Fluid Mechanics and Heat Transfer Facility	O	OAST 81-85 Plan	ND	ND	OAST	J. Lundholm, RSI

SCHEDULE

The following pages show the schedule of mission systems and programs for each basic program category (Planetary, Astrophysics, etc.). All ongoing systems and programs are considered to have a reference start date of CY 1979 and are displayed chronologically using the reported start date.

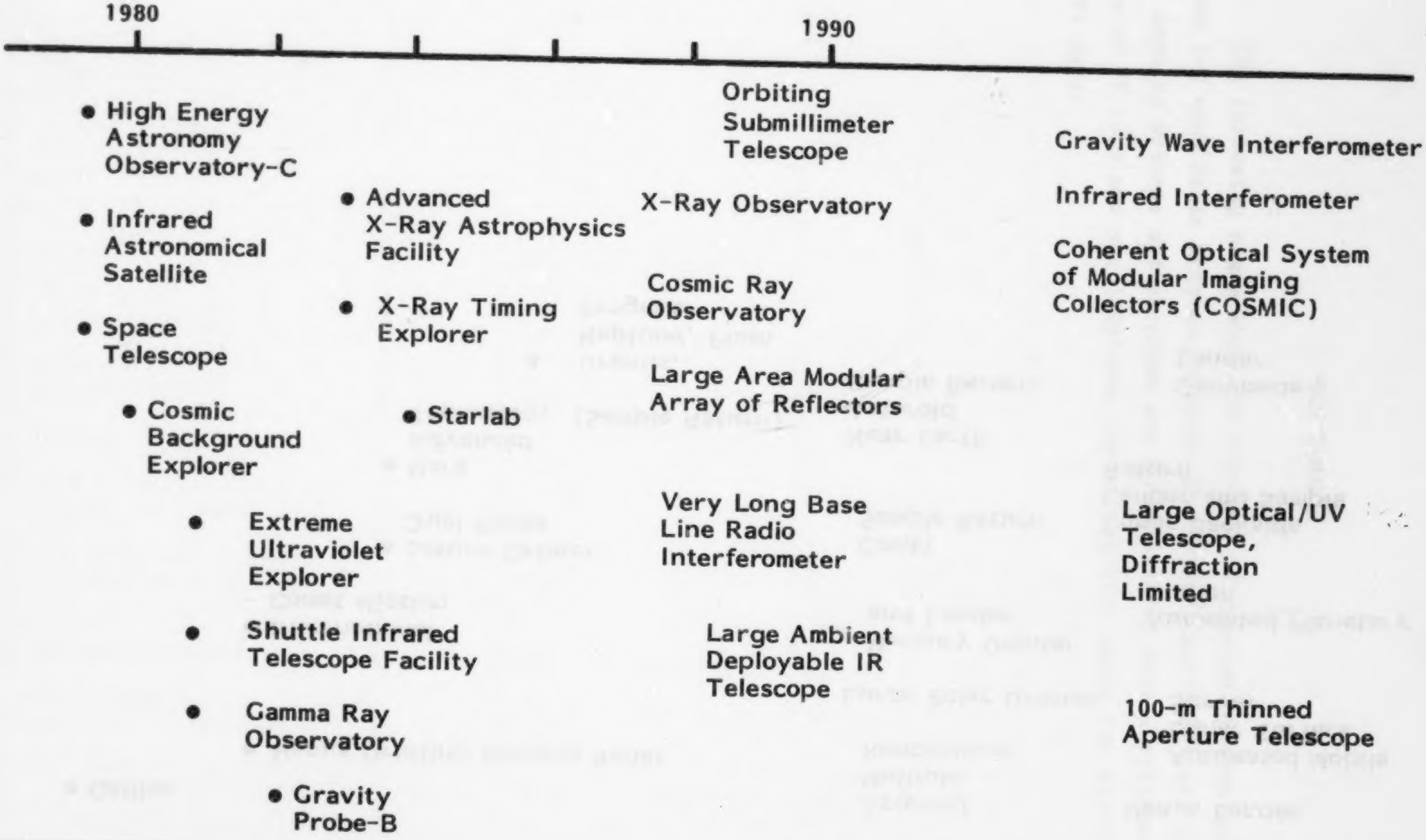
NASA SPACE SYSTEMS TECHNOLOGY MODEL

PLANETARY



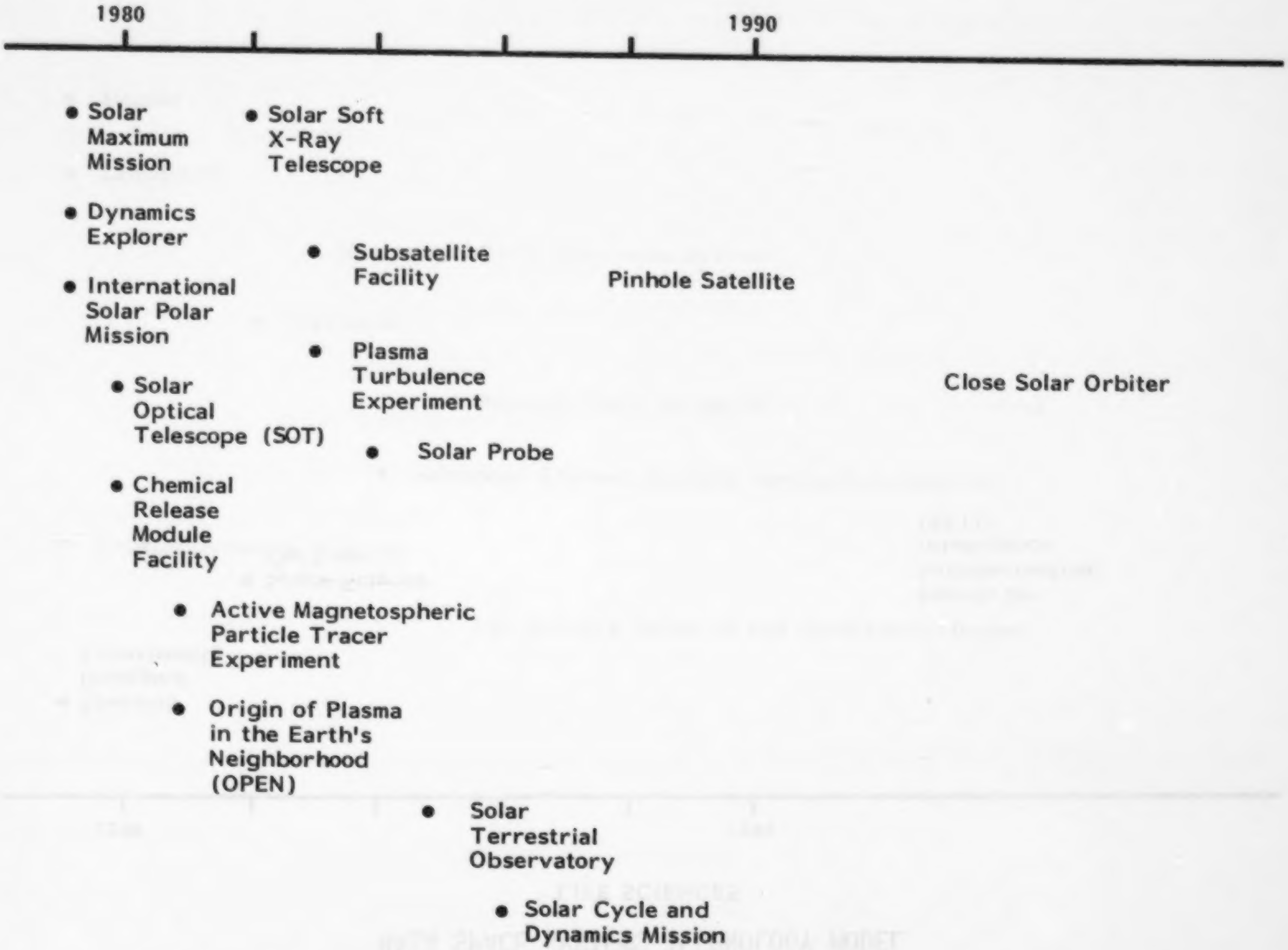
NASA SPACE SYSTEMS TECHNOLOGY MODEL

ASTROPHYSICS


1980
1990
● High Energy Astronomy Observatory-C
● Infrared Astronomical Satellite
● Space Telescope
● Cosmic Background Explorer
● Extreme Ultraviolet Explorer
● Shuttle Infrared Telescope Facility
● Gamma Ray Observatory
● Gravity Probe-B
● Advanced X-Ray Astrophysics Facility
● X-Ray Timing Explorer
● Starlab
Orbiting Submillimeter Telescope
X-Ray Observatory
Cosmic Ray Observatory
Large Area Modular Array of Reflectors
Very Long Base Line Radio Interferometer
Large Ambient Deployable IR Telescope
Gravity Wave Interferometer
Infrared Interferometer
Coherent Optical System of Modular Imaging Collectors (COSMIC)
Large Optical/UV Telescope, Diffraction Limited
100-m Thinned Aperture Telescope

NASA SPACE SYSTEMS TECHNOLOGY MODEL

SOLAR TERRESTRIAL



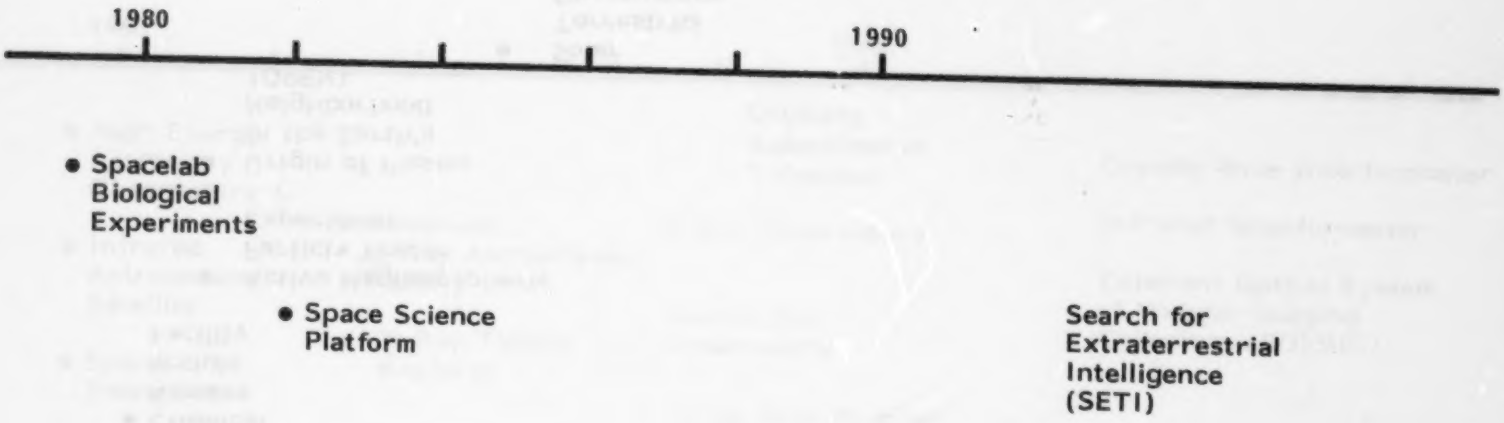
- Solar Maximum Mission
- Solar Soft X-Ray Telescope
- Dynamics Explorer
- Subsatellite Facility
- International Solar Polar Mission
- Plasma Turbulence Experiment
- Solar Optical Telescope (SOT)
- Solar Probe
- Chemical Release Module Facility
- Active Magnetospheric Particle Tracer Experiment
- Origin of Plasma in the Earth's Neighborhood (OPEN)
- Solar Terrestrial Observatory
- Solar Cycle and Dynamics Mission

Pinhole Satellite

Close Solar Orbiter

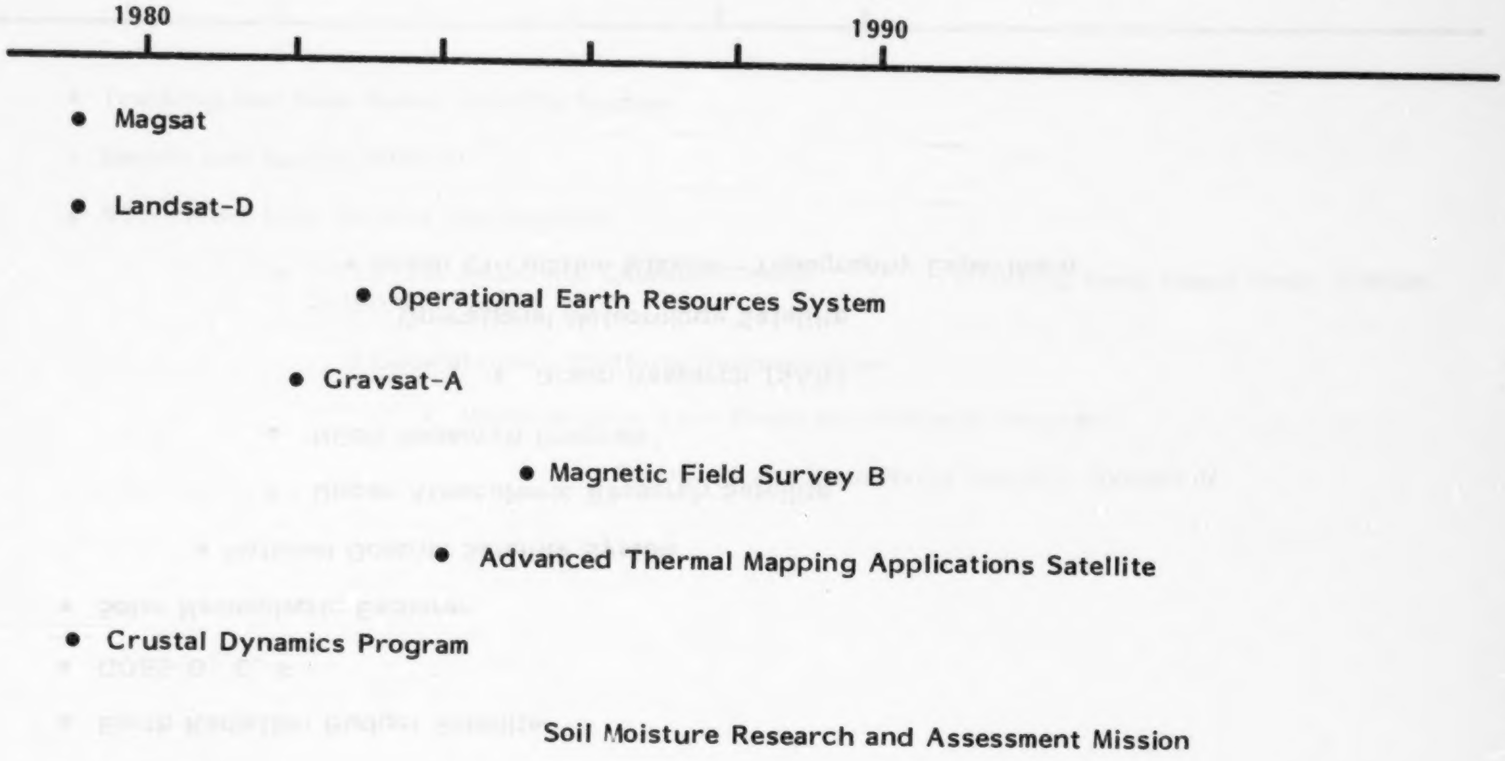
NASA SPACE SYSTEMS TECHNOLOGY MODEL

LIFE SCIENCES



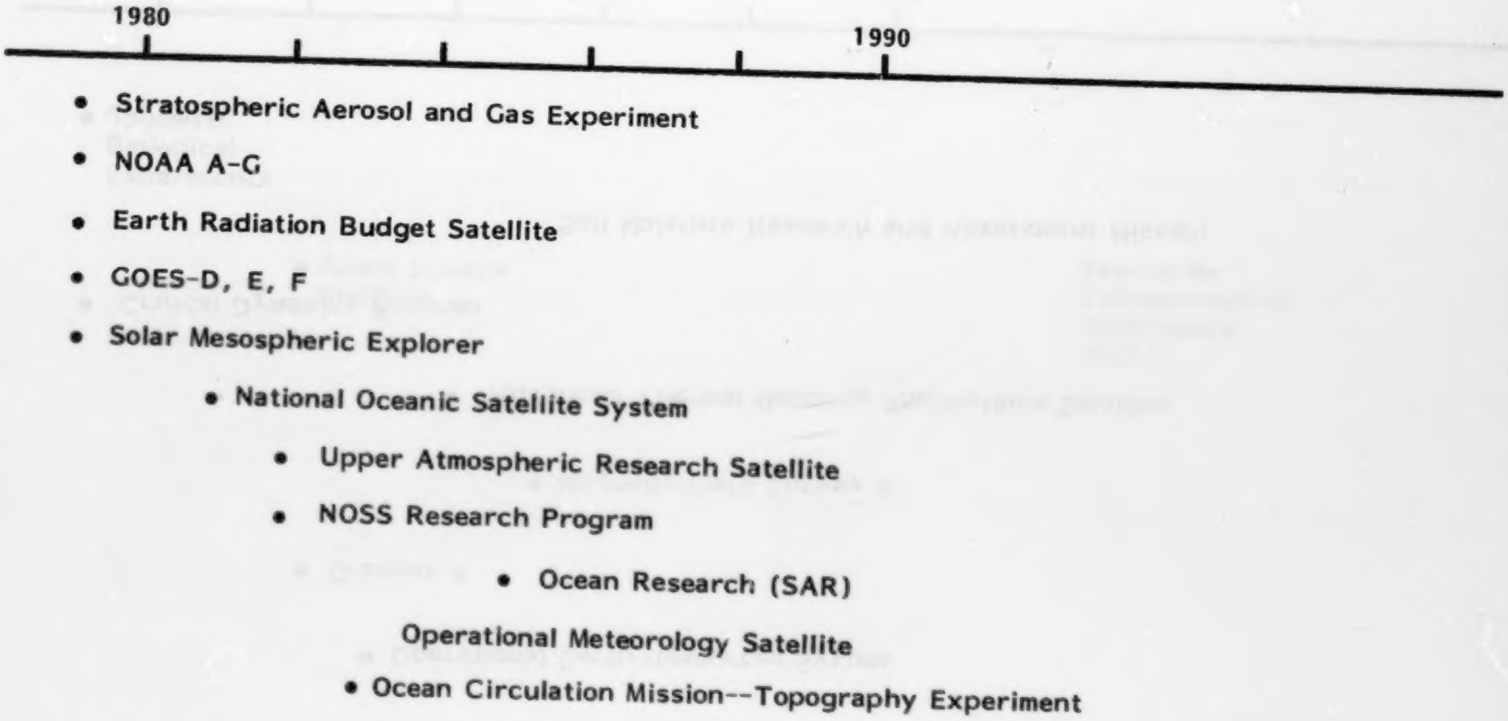
NASA SPACE SYSTEMS TECHNOLOGY MODEL

RESOURCE OBSERVATION



NASA SPACE SYSTEMS TECHNOLOGY MODEL

GLOBAL ENVIRONMENT



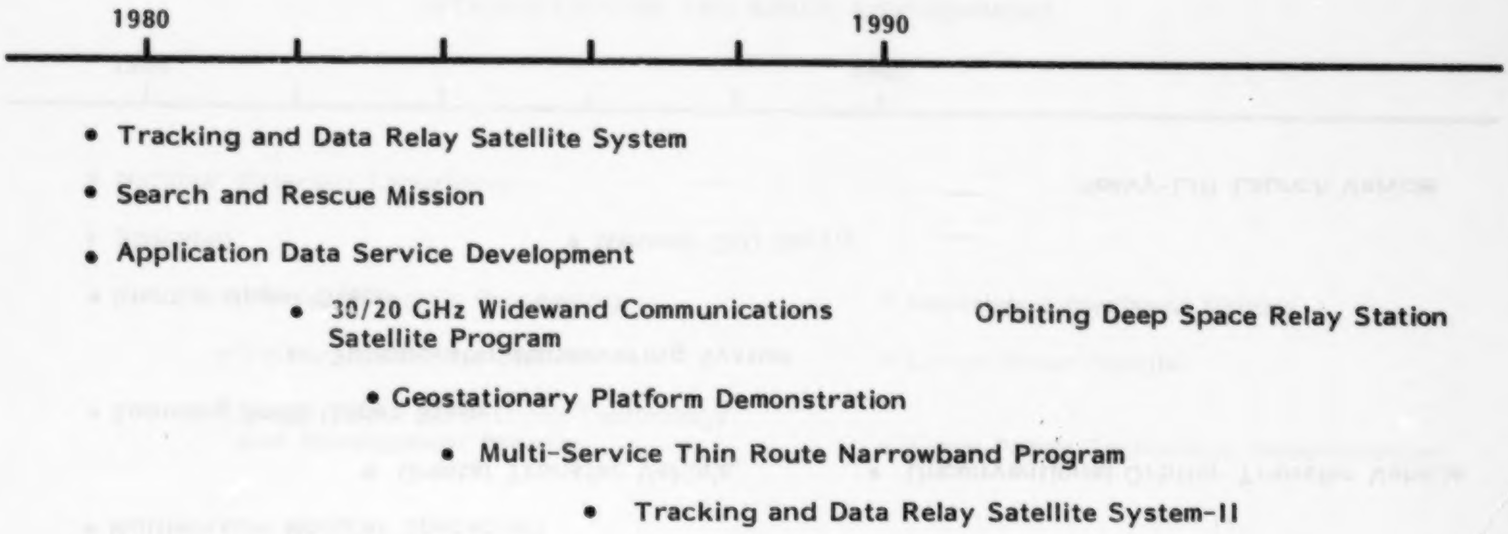
- Stratospheric Aerosol and Gas Experiment
- NOAA A-G
- Earth Radiation Budget Satellite
- GOES-D, E, F
- Solar Mesospheric Explorer
- National Oceanic Satellite System
- Upper Atmospheric Research Satellite
- NOSS Research Program
- Ocean Research (SAR)

Operational Meteorology Satellite

- Ocean Circulation Mission--Topography Experiment

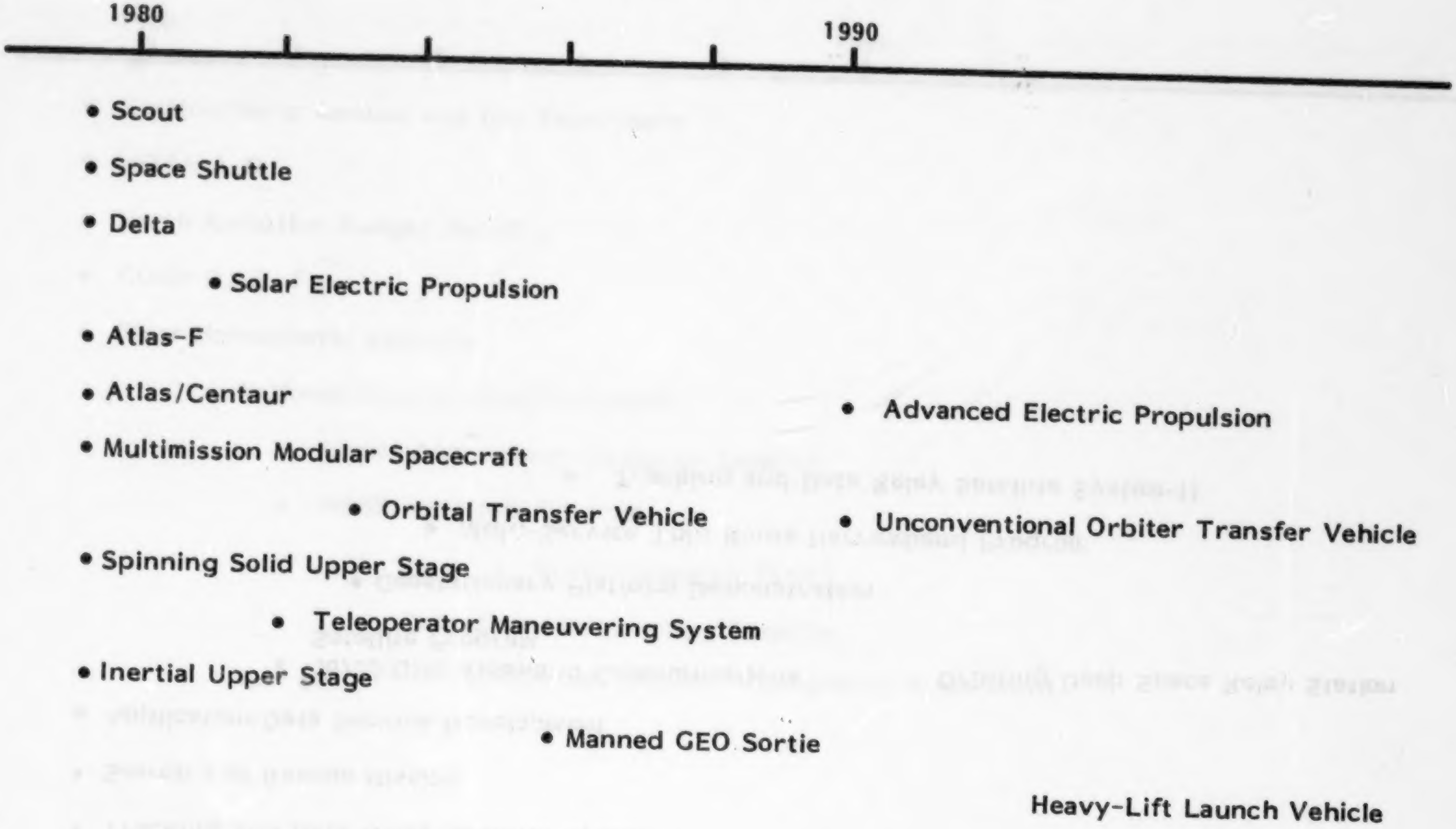
NASA SPACE SYSTEMS TECHNOLOGY MODEL

COMMUNICATIONS



NASA SPACE SYSTEMS TECHNOLOGY MODEL

TRANSPORTATION

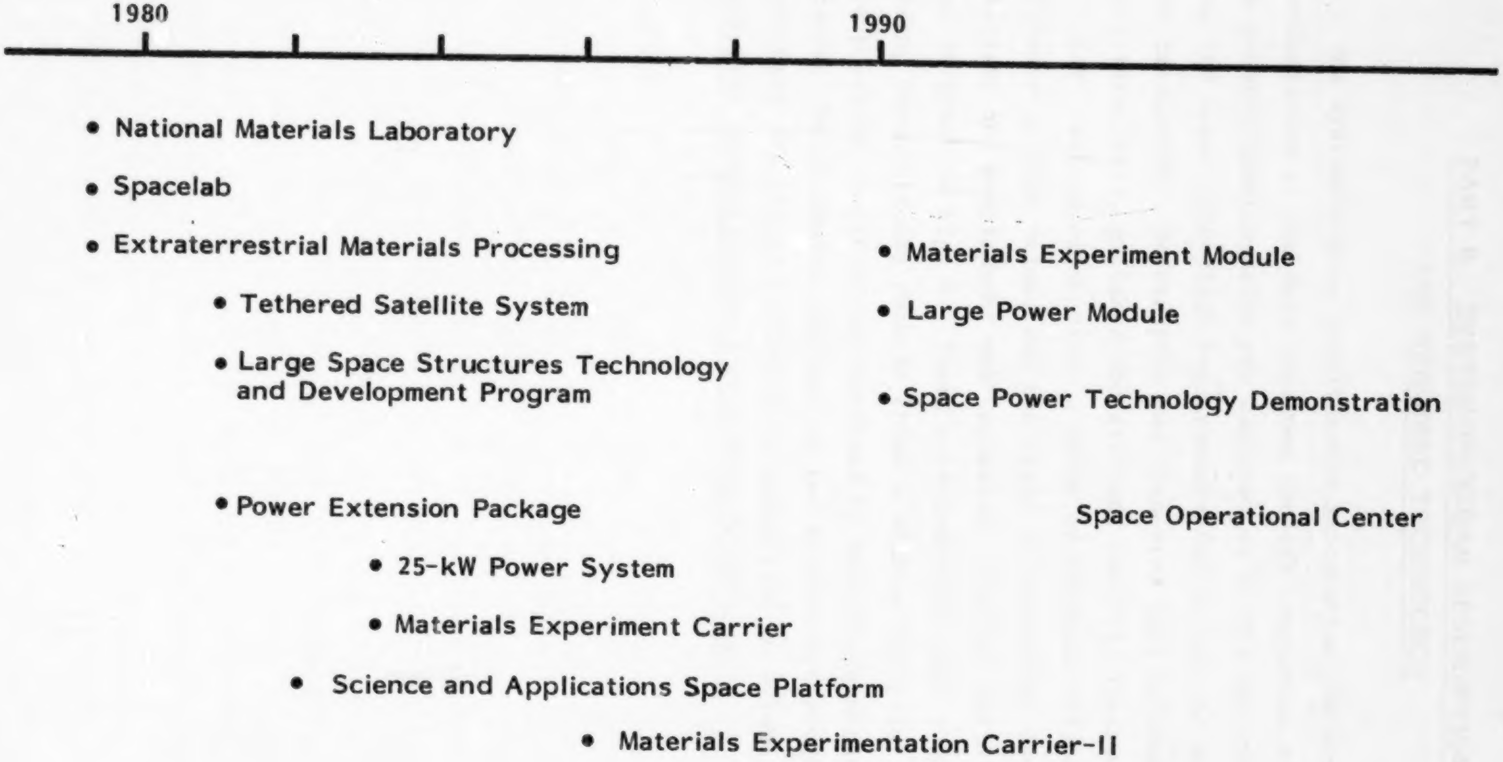


- Scout
- Space Shuttle
- Delta
- Solar Electric Propulsion
- Atlas-F
- Atlas/Centaur
- Advanced Electric Propulsion
- Multimission Modular Spacecraft
- Orbital Transfer Vehicle
- Unconventional Orbiter Transfer Vehicle
- Spinning Solid Upper Stage
- Teleoperator Maneuvering System
- Inertial Upper Stage
- Manned GEO Sortie

Heavy-Lift Launch Vehicle

NASA SPACE SYSTEMS TECHNOLOGY MODEL

UTILIZATION OF THE SPACE ENVIRONMENT



- National Materials Laboratory
- Spacelab
- Extraterrestrial Materials Processing
  - Tethered Satellite System
  - Large Space Structures Technology and Development Program
  - Power Extension Package
    - 25-kW Power System
    - Materials Experiment Carrier
  - Science and Applications Space Platform
    - Materials Experimentation Carrier-II
- Materials Experiment Module
- Large Power Module
- Space Power Technology Demonstration

Space Operational Center

PART B: SYSTEM/PROGRAM DESCRIPTIONS AND REQUIRED TECHNOLOGY

The system/program requirements information contained in Part B is a condensation of the data obtained through completion of a questionnaire. This general questionnaire was designed to elicit information characterizing the space technology requirements for all of the missions in the eight categories. Information was requested that defined physical character, life, data, guidance and attitude control, instruments, propulsion, etc. For each specification, a value or range of values, the degree of confidence in that value, and the state of technology development needed to satisfy the requirement was requested. Further definition of these terms is given in Fig. 4. These questionnaires were completed using existing documentation such as Phase A studies and point designs, and where possible, verified and enriched by NASA Headquarters designated contacts. Requirements information for systems and programs designated Opportunity (O) listed in Part A is summarized in Volume III, Part A: Opportunity Systems/Programs from Program Offices.

TECHNOLOGY REQUIREMENTS

Figure 4

MISSION: ______________________

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
	(a)	(b), (c)	

Data Qualifiers

In the system and program descriptions are found several different symbols to qualify the data. These are:

(a) Confidence in Value and/or Range given (1, 2, 3): 1 = high, a result of at least a Phase B or equivalent study; 2 = result of Phase A or equivalent study; 3 = low, a result of a conceptual or pre-Phase A study. Definition of range: desired value to worst case value. Desired value: the optimistic value which might be reasonably expected based on current views of technology. Worst case value: the value at which the performance of a system would probably become unacceptable.

(b) SOA = present state of the art; EV = evolutionary improvement in SOA expected in time for use; REV - revolutionary improvement probably needed to satisfy requirement. Specifying technology state is not rational for some data items in the Model; it is provided mainly for performance values.

(c) In the absence of values, one of two responses may have been used: NA = not applicable; ND = not determined.

PLANETARY

The Planetary program consists of reconnaissance, exploration, and intensive study missions to various solar system bodies. Reconnaissance missions to seek and identify major characteristics are generally accomplished by flyby spacecraft; exploration missions to discover and understand processes, history, and evolution on a global scale are best accomplished by using orbiting spacecraft in combination with entry bodies and landers; and intensive study missions focused on specific science issues are accomplished using mobile vehicles, sample return or on-location analysis laboratories, and low-altitude polar orbiters.

Investigation of solar system bodies follows an evolution from reconnaissance, through exploration, to intensive study. For Mars and the moon, the exploration phase has been completed and the intensive study realm of investigation is being entered. The reconnaissance phase is nearly completed for Venus and Mercury, and has begun for Jupiter, Saturn, and their moons. Reconnaissance missions to primitive bodies (comets and asteroids), the outer planets, and more satellites of the giant planets are in the planning stages.

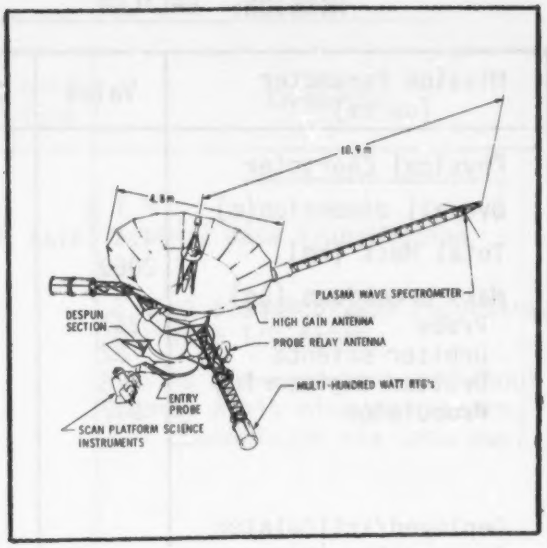
Planetary Missions

NO.	
P-1	Galileo will investigate the chemical composition and physical state of Jupiter's atmosphere, the chemical composition and physical state of the Jovian satellites, and the structure and dynamics of the Jovian magnetic sphere.
P-2	Venus Orbiting Imaging Radar mission is to extend overall scientific knowledge and understanding of Venus and its environment by obtaining a radar map of the surface, determining the figure, measuring the gravity field and investigating the composition, structure and dynamics of the atmosphere.
P-3	International Comet Mission is to determine the physical and chemical characteristics of cometary nuclei and to study the total of cometary phenomena through comparative studies of comets Halley and Tempel 2.
P-4	Saturn Orbiter Dual Probe is to investigate the atmosphere, rings, and magnetosphere of Saturn, the atmosphere of Titan, and the surfaces of the Saturn satellites.
P-5	Mars Advanced Technology is to return samples of the surface and atmosphere of Mars from at least one site.
P-6	Uranus, Neptune, Pluto program is to send spacecraft to Uranus, Neptune, and Pluto as orbiters, probes, and flybys.

PLANETARY

MISSION: GALILEO P-1

Status:	Approved
Lifetime:	5 years including 20 months in orbit
Launch and Transfer Vehicles:	Shuttle/IUS (Twin/Spinner)
Operational Location:	Jupiter orbit
Total Mass at Operational Location:	900 kg
Average Operational Power:	400 w



OBJECTIVE: Galileo is the next important step toward a better understanding of the origin and evolution of the solar system through study of its largest planet, Jupiter. Galileo conducts an intensive investigation of Jupiter by sending an entry probe directly into the dense atmosphere of Jupiter and placing an orbiter around it. The general science objectives of the Galileo mission are to investigate the chemical composition and physical state of Jupiter's atmosphere, the chemical composition and physical state of the Jovian satellites, and the structure and dynamics of the Jovian magnetosphere.

DESCRIPTION: Galileo became an approved program for NASA's Planetary Division in FY 1978. Jet Propulsion Laboratory and Ames Research Center are responsible for the orbiter and probe, respectively. The nominal mission described here calls for the orbiter with probe to be launched in January 1982. The 3.5 year trip to Jupiter includes a Mars gravity assist to reduce launch energy requirements. Probe separation occurs 5 months before Jupiter encounter. The orbiter is then retargeted for an orbit insertion maneuver at 4 R_J and an Io swingby. The orbiter relays the probe data back to Earth prior to orbit insertion. Perijove is raised to 12 R_J during the first 200 day orbit to prepare for Ganymede encounters and to limit radiation dose to the orbiter. Subsequent satellite encounters are used to modify orbit parameters. The Galileo mission is currently being redefined because the Shuttle/IUS was not able to meet the performance requirement in early 1982. Orbiter and probe technology will not be affected; however, a separate flyby spacecraft may be needed to deliver the probe.

CRITICAL TECHNOLOGY NEEDS: Spacecraft attitude control (dual spin); first application of IUS (Twin/Spinner); probe heat shield; first outer planet orbiter and first outer planet entry probe.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Orbiter has CCD imaging, near IR mapper, UV stectrometer, photopolarimeter/radiometer, magnetometer, plasma wave, plasma analyzer, energetic particle detector, dust detector and radio science. Probe has mass spectrometer, He interferometer, atmospheric structure, nephelometer, net flux radiometer and lightning detector.

REFERENCES: Galileo Preliminary Mission and Systems Review, JPL document No. 1625-51, 15 May 1979

CONTACTS: J. Casani, JPL, (213) 354-6578, orbiter
J. Givens, ARC, (415) 965-5696, probe

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: GALILEO Approved P-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	5.1 x 4.4 (dia)	1	Launch configuration.
Total Mass (kg)	2060	1,SOA	
Mass breakdown (kg)			
Probe	257	1,SOA	Includes 25 kg of science.
Orbiter science	82	1	
Orbiter engineering	678	1	
Propulsion	917	1	
Deployed/articulated items, size (m)			
Probe	1.3 (dia)	1	Deployed 5 mo. before Jupiter.
Science boom	10.9	1	
RTG booms (2)	4.0, 5.0	1	Deployed after launch.
Antenna, high gain	4.8 (dia)	1	
Scan platform	1.3	1	Articulated on one axis.
Antenna, probe relay	0.7 (dia)	1	
Life			
Flight duration (yrs.)	4-6	1,SOA	Flight duration includes about 20 months in Jupiter orbit. One orbiter with one probe or one probe plus carrier.
Number of spacecraft	1	1	
Orbit			
Periapse/apoapse altitudes (km)	Varies	1	Initial orbit periapse is 4 R_J, increased to 12 R_J for second orbit. Orbit parameters change following satellite encounters.
Inclination (deg)	Varies	1	

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: GALILEO P-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^{10}	1,SOA	Maximum data transmission.
Storage			
Capacity (bits)	9×10^8	1,SOA	2 NASA Standard tape recorders; variable I/O rates.
I/O rates (kbps)	8-400	1	
Spacecraft processors/ computers			Two 16 bit computers and about twenty 8 bit microprocessors; all cummunicate via data bus.
I/O rates (kbps)	ND	1	
Memory size (bits)	2.5×10^6	1	
Ground Processors/ computers			
Memory size (bits)	ND	1	Use computers at JPL mission control center.
Communications			
Minimum/maximum downlink rates (kbps)	8/115	1,SOA	Digital data transmitted at S-and X-band frequencies to 26 m and 64 m DSN receiving antennas.
Probe relay link rate (bps)	128	1,SOA	Digital data transmitted over one-way UHF link between probe and orbiter (or carrier).
Guidance & Attitude Control			
View direction	Earth	1	Dual spin stabilization; spin axis and, therefore, high gain antenna points to Earth.
Position accuracy (km)	ND	1	
Pointing accuracy (mrad)	1.0	1,SOA	Despun section supports science scan platform which provides accurate and stable pointing for remote sensing instruments. Sensors are star trackers, inertial reference units. Actuators are 10N thrusters, despin system and gimbals.
Stability (mrad)	0.01	1,SOA	

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: GALILEO P-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	380	1,SOA	Power from three radioisotope thermal generators (RTGs); shunt regulated to 30.2 Volts; inverter provides 50 V rms 2.4 kH_z square wave
Peak power consumed (We)	420	1	
Power breakdown (We)			
Sceince	79	1	
Attitude control	111	1	
Telecommunications	62	1	
Commands, data	51	1	
Energy Storage			
Storage capacity (J)	NA		Probe uses lithium batteries.
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
Electronics propellants	280-305	1,SOA	Controlled with sunshades, blankets, heaters and louvers.
Sensors	80-210	1	Near IR mapper and CCD imaging have cooled sensors.
Probe	280		
Component load (Wt)			
Electronics propellants	NA	1	
Sensors	NA	1	
Probe	32	1	Internal radioisotope heater and insulation keep probe warm.

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: GALILEO P-1

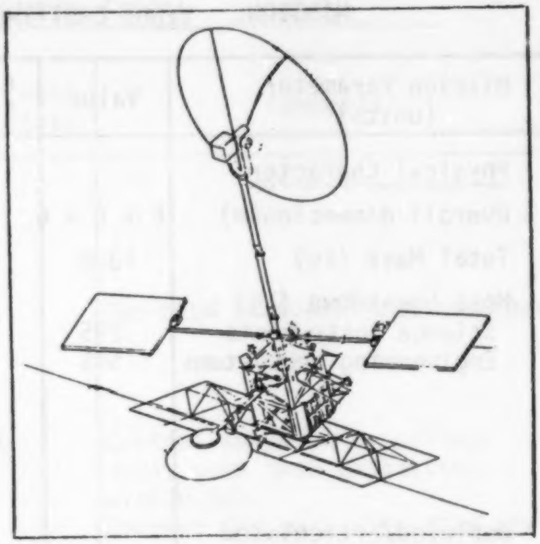
Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical Propulsion			
Total ΔV required (m/sec)	1500	1	Used for orbit insertion, trajectory corrections and backup attitude control.
Number of stages	1	1	
First Stage			
Thrust level (N)	10-400	1,SOA	13 low level thrusters.
Isp (sec)	304	1,SOA	For one high level engine.
Propellant mass (kg)	850	1	Maximum capacity.
Inert mass (kg)	180	1	
Second Stage Thrust level (N) Isp (sec) Propellant mass (kg) Inert mass (kg)	NA		May be necessary if redefined mission has large intermediate impulse (e.g. powered Mars swingby).
Low-Thrust Propulsion			
Input power (kWe)	NA		
Stage mass (kg)			
Propellant (kg)			
Atmospheric Deceleration			
Entry speed (km/sec)	48	1	High velocity results in large heating rate and load. Carbon phenolic ablative heat shield in 45 deg. blunt cone.
Ballistic coefficient (kg/m^2)	161	1,SOA	
Terminal velocity (m/sec)	Varies	1	Use 2.5 m main parachute deployed at Mach 0.95 to control descent speed.

PLANETARY
SENSOR/EXPERIMENT PARAMETERS

MISSION: GALILEO

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
CCD Imaging	Reflected Solar radiance	Spectral range of 0.3 to 1.1 µm (1,SOA); angular resolution of 20 µrad per line pair with a 0.5 deg FOV (1,SOA)	Observations of Jupiter's atmosphere and satellite surfaces. Cooled CCD sensor array with 800 x 800 format. Optics has 1.5 m focal length; it requires precision pointing.
Near Infrared Mapping Spectrometer (NIMS)	Reflected solar radiance	Spectral range of 0.9 to 3.0 µm in 144 channels (1,SOA). Angular resolution of 0.5 mrad. (1,SOA)	Observations of Jupiter's atmosphere and satellite surface minerals. InSb detectors are cooled (1,SOA). Scanning mirror and moveable grating.
Ultraviolet Spectrometer	Atmospheric emissions	Spectral range of 110 to 430 µm in 900 steps (1,SOA)	Study of atmospheric composition, vertical structure and loss rate.
Polarimeter Radiometer	Reflected radiance thermal emission at 1% resolution and polarimetery at 0.1%	Spectral range 0.4 to 1.05 µm in 3 polarimetry and 7 photometry bands (1,SOA)	Studies of cloud and haze properties, satellite surfaces.
Field and Particle Experiments	Magnetic fields, dust energetic particles, plasmas, waves		Solar wind, planetary radiation belts and magnetic fields. Most on spinning part of spacecraft, some on booms.
Atmospheric Structure (probe)	Temperature, pressure and acceleration	Take measurements from 0.1 bar to 10 bar	Determine atmospheric state (temperature, pressure, density and molecular weight).
Neutral Mass Spectrometer (probe)	Atmospheric composition and isotopic abundances	Basic range of 1 to 52 AMU with extension to 131 AMU (1,SOA)	Determine chemical composition and isotope ratios in atmosphere. Quadrupole mass stectrometer (1,SOA)
Net flux Radiometer (probe)	Solar energy and planetary emission	Spectral range of 0.3 to 2000 µm in several broad bands (1,SOA); two 30 deg FOV's	Study energy balance in atmosphere and cloud structure.
Nephelometer (probe)	Reflected light	Emission at 0.9 µm; observe reflections at 5 angles (1,SOA)	Find vertical distribution of clouds, particle size and density.
Lightning Detector (probe)	Optical emissions, radio noise	RF bands at 3,15 and 100 kH_z and one optical sensor (1,SOA)	Verify existence of lightning.

PLANETARY
MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2



Status:	Planned
Lifetime:	1 year
Launch and Transfer Vehicles:	Shuttle/IUS(Twin)
Operational Location:	Venus orbit at 300 km
Total Mass at Operational Location:	1000 kg
Average Operational Power:	1000 w

OBJECTIVE: The purpose of the Venus Orbiting Imaging Radar (VOIR) mission is to extend overall scientific knowledge and understanding of Venus and its environment by obtaining a radar map of the surface, determining the figure, measuring the gravity field and investigating the composition, structure and dynamics of the atmosphere.

DESCRIPTION: Opportunities to launch the VOIR spacecraft occur in November 1984 and May 1986. This description assumes VOIR is approved in FY 81 and launched at the earlier opportunity. The Shuttle/IUS(Twin) places VOIR on its 6 month trajectory to Venus. The spacecraft is inserted into an elliptical orbit (periapse at 300 km and 6 hour period). After a month or two for acquiring gravity and atmosphere data, VOIR's orbit is circularized at a 300 km altitude. After 4 months in this orbit the Synthetic Aperture Radar (SAR) has obtained global coverage in its low resolution mode (pixel resolution of 300 m) and selected coverage at high resolution (50 m). During FY 80, the VOIR mission description is undergoing considerable revision as a result of competitive Phase B studies and a change to the 1986 opportunity.

CRITICAL TECHNOLOGY NEEDS: SAR technology derived from Seasat and from Spacelab experiments. As a result of VOIR requirements, improvements in DSN are planned. Aerobraking has been proposed for orbit circularization.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Synthetic aperture radar including altimetry, radio tracking and possibly additional atmospheric and ionospheric experiments pending Phase B study results and evaluation of responses to the Announcement of Opportunity.

REFERENCES: Mission Description Document for Venus Orbiting Imaging Radar 1984, Jet Propulsion Laboratory document 660-72, 15 October 1978.

CONTACTS: S. Dallas, JPL, (213) 354-7504

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	6 x 6 x 6	2	Flight configuration.
Total Mass (kg)	1000	2	Excludes liquid propellants and solid propellant motors; IUS payload is about 5200 kg.
Mass breakdown (kg)			
Science instruments	295	2	
Engineering subsystems	545	2	
Deployed/articulated items, size (m)			
SAR antenna	12 x 2	2,SOA	Uses Seasat technology.
High gain antenna	5 (dia)	2,SOA	Uses TDRSS technology.
Solar arrays (2)	2 x 2	2	
Altimeter antenna	2	2	
Life			
Flight duration (yrs.)	1	2,SOA	Interplanetary flight takes 5 months, in intermediate orbit for 2 months and at least 4 months in circular orbit for SAR image acquisition. Desire about one year extended mission for additional SAR coverage.
Number of spacecraft	1	2	
Orbit			
Periapse/apoapse altitudes (km)	300	2,SOA	Intermediate orbit is 300 x 19,000 km; final orbit is circular at 300 km altitude. Low eccentricity is essential for SAR imaging.
Inclination (deg)	87	2	
Eccentricity	<0.004	2	

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	2×10^{11}	2,SOA	
Storage			
Capacity (bits)	8×10^9	2,SOA	Two NASA Standard tape recorders.
I/O rates (kbps)	8,192	2	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	2,SOA	Control subsystems, collect data, some data processing within SAR.
Memory size (bits)	ND	2	
Ground Processors/ computers			Convert SAR data into film strip images.
Memory size (bits)	ND	2,SOA	
Communications			
Minimum/maximum downlink rates (kbps)	2,048/ 8,192	2,EV	X-band transmitter on spacecraft sends digital data to DSN 64 m antenna. DSN modifications planned to accommodate this high rate.
Guidance & Attitude Control			
View direction	Nadir	2,SOA	Inertially stabilized using horizon and star sensors, reaction wheels.
Position accuracy (km)	1	2	
Pointing accuracy (mrad)	4	2,SOA	
Stability (mrad)	ND	2	

PLANETARY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	1000	2,SOA	Solar cells provide power.
Peak power consumed (We)	ND	2	
Power breakdown (We)			
Synthetic aperture radar	171/243	2	Low/high resolution modes.
Energy Storage			
Storage capacity (J)	ND	2,SOA	Batteries.
Discharge rate (We)	1000	2	
Discharge/recharge times (min)	30/60	2	
Thermal Control			
Component temperature (K)	ND	2,SOA	Controlled by passive means--blankets, louvers, etc.
Component load (Wt)	ND	2	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical Propulsion			
Total ΔV required (m/sec)	3715	2,SOA	Includes about 285 m/sec for trajectory corrections and orbit sustenance which is provided by monopropellant hydrazine thrusters.
Number of stages	2	2	
First Stage			Used for Venus orbit capture; assume a STAR 48, a solid propellant rocket motor.
Thrust level (N)	6.7×10^4	2,SOA	
Isp (sec)	289	2,SOA	
Propellant mass (kg)	2000	2	
Inert mass (kg)	ND	2	
Second Stage			Used for orbit circularization; assumes a STAR 37XE.
Thrust level (N)	6.2×10^4	2,SOA	
Isp (sec)	288	2,SOA	
Propellant mass (kg)	1325	2	
Inert mass (kg)	ND	2	
Low-Thrust Propulsion			
Input power (kWe)	NA		Not planned, but could be used to increase payload in Venus orbit.
Stage mass (kg)			
Propellant (kg)			
Atmospheric Deceleration			
Entry speed (km/sec)	NA		Not planned, but aerobraking is an option which could be developed for accomplishing orbit circularization; orbited payload is increased.
Ballistic coefficient (kg/m^2)			
Terminal velocity (m/sec)			

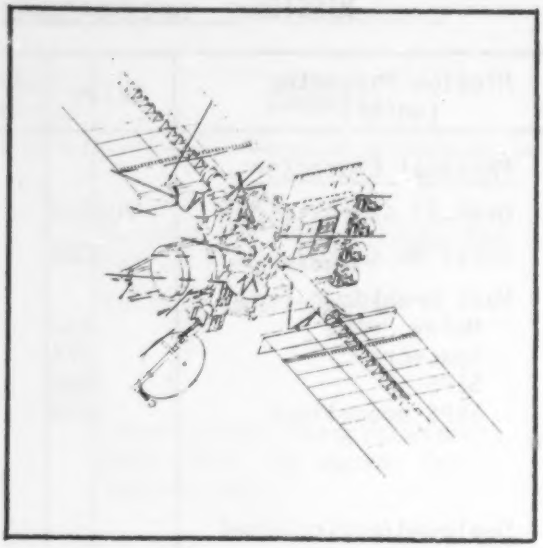
MISSION: VENUS ORBITING IMAGING RADAR (VOIR) P-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Synthetic Aperture Radar	Radio waves reflected from the surface of Venus	Global (90%) coverage at 600 m spatial resolution acquired in 50 km wide swaths, and limited (1-3%) high resolution coverage at 100 m spatial resolution across a 12 km swath (2,SOA)	Obtain images of the surface of Venus through thick clouds. Use to study surface morphology, tectonics, volcanism, etc. Operating, frequency is 1.275 GHz; phased array antenna used to transmit/receive (2,SOA) Look angle is about 50 deg. Determine range (time delay), amplitude and frequency shift of reflected radar pulses.
Altimeter	Range to subspacecraft point		Determine figure of Venus. Part of SAR.

PLANETARY

MISSION: INTERNATIONAL COMET MISSION P-3

Status:	Planned
Lifetime:	4 years launch to end of mission
Launch and Transfer Vehicles:	Shuttle/IUS (Twin) plus SEPS
Operational Location:	Halley flyby and Tempel 2 rendezvous
Total Mass at Operational Location:	2000 kg at Tempel 2
Average Operational Power:	30 kw (for SEPS)



OBJECTIVE: The objective of this mission is to determine the physical and chemical characteristics of cometary nuclei and to study the total of cometary phonemena through comparative studies of comets Halley and Tempel 2. The studies of Halley are conducted during a flyby because this active and less evolved comet is in retrograde orbit. Rendezvous is accomplished with Tempel 2 for the purpose of long term observations of cometary phenomena and close-up studies of the nucleus.

DESCRIPTION: The Solar Electric Propulsion System (SEPS) is used to achieve a trajectory with the Tempel 2 rendezvous and the Halley flyby. SEPS is a proposed FY81 new start for NASA's Office of Space Transportation. The mission module would be developed by the Planetary Division of the Office of Space Science as a FY 82 new start. The European Space Agency proposes to build a probe to be deployed for the Halley flyby. Launch is in July, 1985. The Halley flyby occurs in November 1985 when the comet is at 1.5 AU and is 73 days past perihelion; the relative velocity is 57 km/sec. Tempel 2 rendezvous takes place in July, 1988. the comet perihelion occurs 2 mo. later. Nominal end of mission time is July 1989. An alternate approach to comet exploration is a Halley flyby followed by a later rendezvous mission to Tempel 2 or another short period comet.

CRITICAL TECHNOLOGY NEEDS: This is the first mission for SEPS. A precision pointing control system is desired for closed-loop target tracking.

INSTRUMENT OR EXPERIMENT COMPLEMENT: (Strawman payload; Announcement of Opportunity issued in October, 1979) Imaging, neutral mass spectrometer, charged particle analyzer, magnetometer, dust counter, radar altimeter, and various spectrometers for compositional measurements.

REFERENCES: NASA-ESA Document 626-2 Volumes I-VII

CONTACTS: K. Atkins JPL (213)354-6293

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL COMET MISSION P-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	70x6x6	2, SOA	
Total Mass (kg)	3800	2	Includes fuel
Mass breakdown (kg)			
Haley Probe	250	3	
Spacecraft	725	3	
SEPS	1450	2	
SEPS propellant	1050	2	
Deployed/articulated items, size (m)			
Solar Arrays (2)	4x35	2, SOA	Solar arrays, science scan platform and high gain antenna are articulated.
Halley Probe	2.0x1.5 dia.	3, SOA	
High gain antenna	2 dia.	3, SOA	
Life			
Flight duration (years)	4.0	2	
Number of spacecraft	1	2	Plus deployed probe at Halley
Orbit			
Periapse/apoapse altitudes (km)	NA		Spacecraft approaches Halley at 57 km/sec; closest approach to nucleus is about 100,000/km. Probe is targeted nearer to nucleus. Spacecraft matches orbit of Tempel 2; closest approach to nucleus is more than 1000 km while comet is near perihelian but can be about 100 km later.
Inclination (deg)	NA		

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL COMET MISSION P-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^{10}	2, SOA	Maximum for Halley flyby and Tempel 2 rendezvous
Storage			
Capacity (bits)	9×10^{8}	2, SOA	Galileo tape recorder
I/O rates (kbps)	120	2, SOA	
Spacecraft processors/ computers	1		
I/O rates (kbps)	ND		Distributed microprocessors; data rates low except for imaging data.
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND		Will use existing capabilities.
Communications			
Minimum/maximum downlink rates (kbps)	7.5-120	2, SOA	
Uplink rate (kbps)	ND	2	
Guidance & Attitude Control			
View direction	Thrust direction	2	Sensors star/sun sensors, monopulse receiver, target and gyros. Very accurate pointing required for imaging and antennas. 2 DOF actuators provide basic altitude control via thrust vectoring/ momentum wheels.
Position accuracy (km)	ND	2	
Pointing accuracy (mrad)	ND	2	
Stability (mrad)	ND	2	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL COMET MISSION P-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	350	2	Provided by SEPS
Peak power consumed (We)	700	2	Available when SEPS thrust is off.
Power breakdown (We)	ND	2	
Energy Storage	NA		
Storage capacity (J)			
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)	ND	3	
Component load (Wt)	ND	3	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL COMET MISSION P-3

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	NA		
Number of stages			
First Stage			
Thrust level(N)			
Isp (sec)			
Propellant mass (kg)			
Inert mass (kg)			
Second Stage			
Thrust level(N)			
Isp (sec)			
Propellant mass (kg)			
Inert mass (kg)			
Low-Thrust Propulsion			
Input power (kWe)	31.6	2, SOA	This is first planned flight for SEPS.
Stage mass (kg)	1450	2, SOA	
Propellant (kg)	1050	2	
Atmospheric Deceleration			
Entry speed (km/sec)	NA		
Ballistic coefficient (kg/m^2)			
Terminal velocity (m/sec)			

PLANETARY

SENSOR/EXPERIMENT PARAMETERS

MISSION: INTERNATIONAL COMET MISSION

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Imaging	Reflected solar radiance and comet emissions	Spectral range of 0.3 to 1.1 μm (3, SOA) angular resolution is 10 μrad. FOV is 0.5 deg.	CCD array sensors; 800 x 800 format (3, SOA). Used for target tracking, nucleus and coma investigations at high angular resolution. Precision pointing required.
Radar Altimeter	Distance to comet nucleus from <600 km with 25m resolution.	Velocity resolution of 1 m/sec. Angular resolution of 1 deg.	Antenna diameter of 1 to 2 m; operating frequency of 8 to 10 GHz; peak transmitted power of 40 to 100 w. Data used for navigation, mass determination and surface properties.
Neutral Mass Spectrometer	Composition, density of gases in coma		Details not available. These instruments to be designed and built by principal investigators. Announcement of Opportunity issued October 1979.
Charged Particle Analyzer	Composition, density of ions/electrons in coma/tail and solar wind.		
Dust Counter	Density, size and perhaps composition of dust particles		
Photon Spectrometer	Emissions absorption by coma, dust, nucleus		
Magnetometer and Plasma Wave	Magnetic field and low frequency radio waves resulting from solar wind interactions.		

PLANETARY

MISSION: SATURN ORBITER DUAL PROBE P-4

Status:	Planned
Lifetime:	8-12 years, includes 3 years in Saturn orbit.
Launch and Transfer Vehicles:	Shuttle/IUS (Twin) plus SEPS
Operational Location:	Saturn orbit
Total Mass at Operational Location:	2000 to 3600 kg at Saturn approach
Average Operational Power:	450 to 600 w. plus 30 kw for SEPS

OBJECTIVE: The mission objectives are to investigate the atmosphere, rings and magnetosphere of Saturn and the atmosphere of Titan and the surfaces of Titan and the other satellites of Saturn. All investigations are conducted using remote sensing experiments on an orbiting spacecraft and in the case of the atmospheres of Saturn and Titan and the surface of Titan by in-situ experiments on atmospheric probes.

DESCRIPTION: The nominal mission uses a low-thrust trajectory with two Earth swingbys (at 15 and 29 months after launch) prior to Saturn encounter which occurs 8 years after launch. SEPS thrust is used periodically between launch and the second Earth swingby. The Saturn probe is separated on approach and the spacecraft retargeted for probe support and orbit capture. The orbit periapse is raised to effect Titan encounters and Titan probe deployment. A tour of other satellites is achieved using gravity assists from Titan. Options being studied are orbiters with only one probe and flyby spacecraft to deploy one or two probes. Aerocapture in Titan's atmosphere is being considered to replace retropropulsion. Both the orbiter and probe make extensive use of Galileo technology. Preproject planning has been initiated so that NASA's Planetary Division could propose this mission for a FY83 new start with launch in November, 1987.

CRITICAL TECHNOLOGY NEEDS: Improvements in long distance telecommunications and/or data compression techniques; long life components; aerocapture (optional).

INSTRUMENT OR EXPERIMENT COMPLEMENT: Strawman orbiter and Saturn probe payloads are same as Galileo. Saturn and Titan probes also include preentry science (plasma instruments, other particles and fields experiments). Titan probe makes surface measurements (imaging, x-ray and gamma ray spectrometers.

REFERENCES: "Saturn Orbiter Dual Probe Mission Concept", JPL Document No. 710-20, September 1978.
"Study of Entry and Landing Probes for Exploration of Titan", Martin-Marietta Corp., NASA CR 152275, March 1979.

CONTACTS: D. Pivirotto, JPL, (213)354-3917
J. Murphy, ARC, (415)965-6525 (probes)

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SATURN ORBITER DUAL PROBE P-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	70x5x5	3, EV	Configuration complicated by presence of 2 probes, orbit capture propulsion and SEPS
Total Mass (kg)	3600	3, SOA	
Mass breakdown (kg)			
Mission module	850	3, SOA	Includes 140 kg of instruments
Probes (2)	550	3, SOA	Each includes 45 kg of instruments
Chemical Propulsion	2200	3, SOA	
Deployed/articulated items, size (m)			
Science booms	10-20	3, SOA	
RTG boom	3	3, SOA	
Solar array	30x5	3, SOA	
High gain antenna	4-6 (dia)	3, SOA	
Life			
Flight duration (years)	8-12	3, EV	
Number of spacecraft	1-2		
Orbit			
Periapse/apoapse altitudes (km)	variable	3	
Inclination (deg)	low	3	Titan gravity assist used to alter orbit

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SATURN ORBITER DUAL PROBE P-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	3×10^9	3, SOA	Similar to Galileo
Storage			
Capacity (bits)	9×10^8	3, SOA	Tape recorder
I/O rates (kbps)	115	3, SOA	
Spacecraft processors/ computers			Distributed microprocessors; low data rates except for imagery data. Data compression would reduce data link requirements.
I/O rates (kbps)	ND		
Memory size (bits)	ND		
Ground Processors/ computers			Use existing equipment for science data. Could use automated spacecraft monitoring to reduce cruise manpower requirement.
Memory size (bits)	ND		
Communications			
Minimum/maximum downlink rates (kbps)	1-115	3, EV	Link improvements needed because Saturn is about 10 AU from Earth.
Uplink rate (kbps)	0.2	3, SOA	
Guidance & Attitude Control			
View direction	Earth	3, SOA	High gain antenna points to Earth. Dual spin, 3 axis stabilized and single spin all being considered for orbiter. Stability & pointing requirements are currently the same as for Galileo. (Probes are spin-stabilized)
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	1.0	3, SOA	
Stability (mrad)	0.01	3, SOA	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SATURN ORBITER DUAL PROBE P-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	450	3, SOA	Radioisotope thermal generators (RTG)
Peak power consumed (We)	450	3, SOA	Nominal is Galileo plus additional power for longer mission and communication from Saturn.
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	NA	3	Probes use batteries
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
electronics	280	3, SOA	
sensors	ND	3	Cooled CCD camera, others(?)
propellant	ND	3	May be space storable
Component load (Wt)			
electronics	ND	3	Use blankets, louvers
sensors	ND	3	Radiators, blankets, heaters
propellant	ND	3	Blankets

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SATURN ORBITER DUAL PROBE P-4

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	2450	3, SOA	ΔV requirement includes navigation, probe deployments, orbit insertion and satellite targetting for gravity assists. ΔV requirements can be reduced by aerocapture and propellant is less with space storable technology.
Number of stages	1	3	
First Stage			
Thrust level(N)	ND	3	
Isp (sec)	ND	3	
Propellant mass (kg)	1825	3	
Inert mass (kg)	375	3	
Second Stage			
Thrust level(N)			
Isp (sec)			
Propellant mass (kg)			
Inert mass (kg)			
Low-Thrust Propulsion			
Input power (kWe)	30	3, SOA	Same as for International Comet Mission.
Stage mass (kg)	1450	3, SOA	
Propellant (kg)	800	3, SOA	
Atmospheric Deceleration			
Entry speed (km/sec)	~30/~6	3, SOA	Saturn/Titan entry velocities. Requirements for probe systems depend upon trajectory and deployment option selections. Entry easier than Galileo.
Ballistic coefficient (kg/m^2)	ND		
Terminal velocity (m/sec)	ND		

PLANETARY

SENSOR/EXPERIMENT PARAMETERS

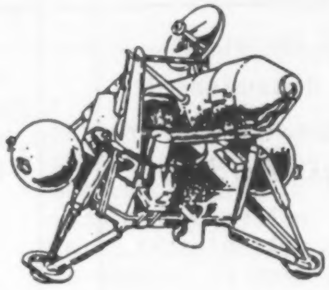
MISSION: SATURN ORBITER DUAL PROBE

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Imaging	Reflected solar radiance	Spectral range of 0.3 to 1.1μm (3,SOA) angular resolution of 10 μrad and FOV of 0.5 deg. (3,SOA)	CCD array sensor; 800 x 800 format (3,SOA). Used for satellite surfaces, Saturn and Titan atmospheres and rings. Precision pointing required.
Near IR Spectrometer	Reflected solar radiance	Spectral range of 1 to 5 μm (3,SOA)	The composition and structure of atmospheres and composition of satellites and rings are deduced from spectra
UV Spectrometer	Atmospheric emissions	Spectral range of 0.05 to 0.3 μm (3,SOA)	Composition and structure of upper atmosphere
Magnetometer	Magnetic field vector		Solar, planetary magnetic fields
Particle Detectors	Changed particle flux, composition		Solar wind, planetary radiation belts, low energy cosmic rays
Atmospheric Structure (probe)	Atmospheric pressure and temperature and descent velocities		Pressure, temperature measured directly, and by fit to probe velocity vs. time.
Neutral Mass Spectrometer (probe)	Atmospheric composition and abundance	Range of 1 to 50 AMU (3,SOA)	Should include gas chromatograph, too.
Spectral Flux Radiometer (probe)	Thermal flux in various directions		Determines energy balance in atmosphere.
Nephelometer (probe)	Reflected solar radiance in various directions		Detects light scattered by clouds.

PLANETARY

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Status:	Planned
Lifetime:	3 years launch to sample return
Launch and Transfer Vehicles:	Shuttle/IUS (Twin)
Operational Location:	Mars orbit and surface
Total Mass at Operational Location:	3,000 to 10,000 kg
Average Operational Power:	200 to 2,000 w



OBJECTIVE: The purpose of this mission is to return samples (> 1kg) of the surface and atmosphere of Mars from at least one site. The samples are to be examined in Earth-based laboratories using many sophisticated techniques. Detailed geochemical, geophysical, biological and biochemical investigations are expected to increase understanding of the origin and evolution of Mars.

DESCRIPTION: There are three options for accomplishing this mission. The first requires two Shuttle launches--one for a lander/ascent vehicle and one for an orbiter. The orbiter waits for the ascent vehicle to bring the sample to the Earth return vehicle. The second option includes O_2 propellant manufacture on Mars and direct return from the surface of Mars to the Earth. Aerocapture can be used to orbit Mars prior to landing to search for landing sites and to deploy a supporting orbiter spacecraft. The third option uses aerocapture to place the return and lander/ascent vehicles in Mars orbit where the return vehicle awaits the arrival of the sample carried by the ascent vehicle. No project start date is defined. However, studies are underway to define mission and technology requirements for a start in FY 84 or FY 85.

CRITICAL TECHNOLOGY NEEDS: Autonomous rendezvous, stationkeeping and docking for the purpose of sample transfer are needed for options 1 and 3. Aerocapture is needed for options 2 and 3. Automated in-situ propellant production is required by option 2.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Instruments to support site selection and sample documentation would include imagery and other techniques not yet identified.

REFERENCES: "Mars Program Vehicle Options", JPL Document No. 720-14, May 1978.

CONTACTS: J.R. French, JPL, (213)354-5602

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	ND	3	
Total Mass (kg)	3,000-10,000	3	
Mass breakdown (kg)	ND	3	
Deployed/articulated items, size (m)			
Solar arrays (orbiter)	1x3	2, SOA	
Manipulator(s) (lander)	2	2, EV	Small rover is alternative
Life			
Flight duration (years)	3	3	
Number of spacecraft	ND	3	Depends on mission mode
Orbit			
Periapse/apoapse altitudes (km)	500/500	2, SOA	Site selection rendezvous or data relaying. Synchronize with surface location of lander.
Inclination (deg)			
Aerocapture altitude (km)	18	2, EV	For aerocapture, guidance accuracy is important since B plane accuracy defines entry corridor width.

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3, SOA	Depends heavily on mission mode such as amount of science on orbiter, degree of autonomy in sample acquisition, autonomy in station-keeping docking, etc. In general it does not appear that this mission will push data systems beyond SOA.
Storage			
Capacity (bits)	ND	3, SOA	
I/O rates (kbps)	ND	3, SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, SOA	
Memory size (bits)	ND	3, SOA	
Ground Processors/ computers			
Memory size (bits)	ND	3, SOA	
Communications			
Minimum/maximum downlink rates (kbps)	ND	3, SOA	Orbiter via DSN. Lander may communicate direct or relay through orbiter (if there is one) Does not appear to exceed SOA. All data is digital; transmitted S- or X-band.
Uplink rate (kbps)	ND		
Guidance & Attitude Control			
View direction	ND	3, SOA	
Position accuracy (km)	Varies	3, EV	Position accuracy needed during rendezvous, docking is about 1% of range; prefer laser system to radar. Lander spececraft could use terminal guidance to reduce landing error to about 3km or a system which allows it to detect and avoid hazards; either option increases landing site availability.
Pointing accuracy (mrad)	ND	3, SOA	
Stability (mrad)	ND	3, SOA	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	300	3, SOA	RTG for lander; photovoltaic for orbiter. Increases to about 2000 w for propellant production; needs EV technology nuclear power source.
Peak power consumed (We)	ND		
Power breakdown (We)	ND		
Energy Storage			For orbiter occultations, peak loads on lander, and possibly also small rover use NiCd or lithium batteries. There does not appear to be any unique requirement beyond SOA.
Storage capacity (J)	ND	3, SOA	
Discharge rate (We)	ND	3, SOA	
Discharge/recharge times (min)	ND	3, SOA	
Thermal Control			
Component temperature (K)			
Sample canister	-40°C	2, EV	From acquisition to return to Earth, maintaining sample at low temperature is critical for biology and surface chemistry. Cryogenic liquids associated with propellant production option only.
O_2/CH_4	-165°C	2, EV	
Component load (Wt)			
Sample canister	ND		
O_2/CH_4	ND		

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	variable	2	Total ΔV and number of stage parameters depend upon option selected. The first option could have as many as 8 stages. Both orbiters have a stage used for orbit insertion; the lander has stages for deorbit and terminal decent; the ascent vehicle has a stage for Mars departure and perhaps one for Earth orbit insertion. Other options have fewer stages because of aerocapture and direct return. Solids and Earth storable propellants used except that O_2 and CH_4 are used when propellant is produced on Mars.
Number of stages	variable	2	
First Stage Thrust level(N) Isp (sec) Propellant mass (kg) Inert mass (kg)			
Second Stage Thrust level(N) Isp (sec) Propellant mass (kg) Inert mass (kg)			
Low-Thrust Propulsion			
Input power (kWe)	NA		
Stage mass (kg)	NA		
Propellant (kg)	NA		
Atmospheric Deceleration			Aerocapture into orbit is an option. High-speed atmospheric entry and a parachute descent are assumed for landers.
Entry speed (km/sec)	ND	3, SOA	
Ballistic coefficient (kg/m^2)	ND	3, SOA/EV	
Terminal velocity (m/sec)	ND	3, SOA	

PLANETARY

SENSOR/EXPERIMENT PARAMETERS

MISSION: MARS ADVANCED TECHNOLOGY (Sample Return) P-5

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Sample Analysis	Many different properties	ND	Measurements of returned samples in an Earth-based laboratory using sophisticated and sensitive techniques.
Sample Documentation	Several different properties	ND	Select several techniques (e.g., imaging, x-ray, γ-ray,)α particle to be used on lander for documentation of collected samples
Remote Sensing (orbiter)	Several different properties	ND	Imaging, spectrometers used to select the landing site and characterize it relative to Martian global features.
Sample Monitoring (return vehicle)	Sample environment	ND	Record sample temperatures, pressure, radiation exposure after collection.

PLANETARY

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Status:	Candidate
Lifetime:	7-20 years
Launch and Transfer Vehicles:	Shuttle/IUS(Twin)/ Spinner (SEPS for orbiter)
Operational Location:	Uranus orbit, U, N and P flyby
Total Mass at Operational Location:	600-1000 kg
Average Operational Power:	450 W

OBJECTIVE: Within a single program, spacecraft are to be sent to Uranus, Neptune and Pluto. An orbiter is planned for Uranus, atmospheric entry probes are desired at Uranus and Neptune, and flybys of Neptune and Pluto are envisioned. This program is a logical extension of the exploration performed by Voyager and Galileo.

DESCRIPTION: Favorable launch opportunities using Jupiter swingby trajectories to Urnaus, Neptune and Pluto exist in the period 1990 to 1994. A single exploration program which sends spacecraft to each is an attractive future opportunity. Program objectives could be met at reasonable cost by using Galileo technology where possible and by using as few nearly identical spacecraft as possible to perform the desired exploration program.

CRITICAL TECHNOLOGY NEEDS: Long lifetime, long distance communications, much larger data storage capability, and better automated operation.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Measurement techniques used on Voyager/Galileo are likely to be used for this program, with higher sensitivity in some cases.

REFERENCES:

CONTACTS: J. C. Niehoff, Science Applications, Inc. (312)885-6800
R. A. Wallace, JPL (213)354-6162

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	ND	3	
Total Mass (kg)	600-1000		
Mass breakdown (kg)	ND	3	
Deployed/articulated items, size (m)			
Atmospheric Probe(s)	1x1.3 (dia)	3, SOA	Like Galileo probe
Science boom(s)	10-20	3, SOA	For magnetometer, plasma wave experiments
Science scan platform	ND	3, SOA	Articulated in 1 to 2 axes.
RTG boom(s)	3	3, SOA	
High gain antenna	5-10 (dia)	3, SOA	Large antenna for long distance communication.
Life			
Flight duration (years)	7-20	3, EV	
Number of spacecraft	2-3	3	
Orbit			
Periapse/apoapse altitudes (km)	ND	3	Interplanetary and flyby trajectories and Uranus orbit may depend upon launch opportunity and launch vehicle capability.
Inclination (deg)	ND	3	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^9	3, SOA	Less than Galileo, limited by data link capability.
Storage			
Capacity (bits)	10^9-10^{11}	3, SOA-EV	Larger capacity to increase data from flyby missions (EV).
I/O rates (kbps)	120	3, SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, SOA	Distributed microprocessors; low data rates except for imaging. Data compression desired to compensate for lower data transmission rates.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3, SOA	Using existing equipment for science data. Could use automated spacecraft monitoring during cruise phases of missions.
Communications			
Minimum/maximum downlink rates (kbps)	ND	3, EV	Digital data sent to DSN via X-band link. Performance improvement needed to communicate over longer distances.
Uplink rate (kbps)	ND	3, SOA	
Guidance & Attitude Control			
View direction	Earth	3, SOA	High gain antenna points toward Earth. Science articulated to point at planet, satellites and rings. Stabilization method not determined, but probably similar to Galileo, Voyager or Pioneer. Autonomy needed because of long round-trip communication time.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	1.0	3, SOA	
Stability (mrad)	0.01	3, SOA	

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	450	3, SOA	Radioisotope thermal generators (RTG). Requirement somewhat more than Galileo because of longer lifetimes and communications distances.
Peak power consumed (We)	450	3, SOA	
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	ND	3	Probes use batteries.
Discharge rate (We)	ND	3	
Discharge/recharge times (min)	ND	3	
Thermal Control			
Component temperature (K)			
electronics	280	3, SOA	?
sensors	ND	3, SOA	Cooled CCD camera, others(?)
propellants	ND	3, SOA	Orbiter may use space storable propellants.
Component load (Wt)			
electronics	ND	3	Use blankets, louvers
sensors	ND	3	radiators, blankets, heaters
propellants	ND	3	blankets

PLANETARY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	100-2500	3, SOA	Low value typical for flybys with probes and higher value typical for Uranus orbiter. Propulsion system is Earth-storable or space-storable. Used for trajectory correction, probe deployments, and, in the case of the Uranus orbiter, for orbit insertion and adjustments.
Number of stages	1	3	
First Stage			
Thrust level(N)	ND	3	
Isp (sec)	ND	3	
Propellant mass (kg)	ND	3	
Inert mass (kg)	ND	3	
Second Stage			
Thrust level(N)			
Isp (sec)			
Propellant mass (kg)			
Inert mass (kg)			
Low-Thrust Propulsion			
Input power (kWe)	30	3, SOA	
Stage mass (kg)	1450	3	Uranus orbiter mission may use SEEGA trajectory. Could be same system as for International Comet Mission.
Propellant (kg)	800	3	
Atmospheric Deceleration			
Entry speed (km/sec)	25-30	3, SOA	Used for entry and decent of atmospheric probes. Requirements are similar to Saturn probes.
Ballistic coefficient (kg/m^2)	ND	3	
Terminal velocity (m/sec)	ND	3	

PLANETARY

SENSOR/EXPERIMENT PARAMETERS

MISSION: URANUS, NEPTUNE, PLUTO PROGRAM P-6

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Imaging	Reflected solar radiance	Spectral range of 0.3 to 1.1μm, (3,SOA) angular resolution of 10 μrad and FOV of 0.5 deg. (3,SOA)	CCD array sensor; 800 x 800 format (3,SOA). Used for satellite surfaces, planet atmospheres and rings. Precision pointing required.
Near IR Spectrometer	Reflected solar radiance	Spectral range of 1 to 5μm (3,SOA)	The composition and structure of atmospheres and composition of satellites and rings are deduced from spectra.
IR Radiometer	Emitted thermal radiation	Spectral range of 5 to 100 μm (3,SOA) subdivided into several broad bands.	For determining the temperatures of atmospheres, satellites and rings.
UV Spectrometer	Atmospheric emissions	Spectral range of 0.05 to 0.3 μm (3,SOA)	Composition and structure of upper atmosphere.
Magnetometer	Magnetic field vector		Solar, planetary magnetic fields.
Particle Detecters	Charged particle flux, composition		Solar wind, planetary radiation belts, low energy cosmic rays.
Atmospheric Structure (probe)	Atmospheric pressure and temperature and decent velocities		Pressure, temperature measured directly, and by fit to probe velocity vs. time.
Neutral Mass Spectrometer (probe)	Atmospheric composition and abundance	Range of 1 to 50 AMU. (3,SOA)	Should include gas chromatograph, too.
Spectral Flux Radiometer (probe)	Thermal flux in various directions		Determines energy balance in atmosphere.
Nephelometer (probe)	Reflected solar radiance in various directions		Detects light scattered by clouds.

ASTROPHYSICS

The Astrophysics program strategy is first to identify sources and new phenomena; then to catalog sources by making "all sky" surveys in appropriate wavelengths; then to study identified sources with high-resolution observatories; and then finally to make correlative studies of the sources in all appropriate wavelengths in order to develop a complete understanding of the phenomena and objectives involved. In addition to investigations of electromagnetic and particle radiation, research is to be conducted in relativity, gravitation, and other relevant physical areas.

The basic techniques used in astrophysics are imaging, spectrometry, photometry, and polarimetry. Current efforts are performed in low earth orbit and are most advanced in the "classical" regions of the spectrum (visible and IR) due to the extensive ground-based historical studies. A primary focus of this program is in those parts of the spectrum obscured by the earth's atmosphere, such as gamma rays, X-rays, the ultraviolet, and much of the IR and radio region, where space-based measurements are essential.

In order to progress from the small, specialized astrophysics spacecraft of today to the large multi-instrument spacecraft of the future, a bootstrap approach is being considered. This would entail shifting Shuttle-mounted instrumentation to Shuttle-tended free-flyers or large multi-instrument platforms.

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Astrophysics Missions

NO.	
A-1	High Energy Astronomy Observatory-C is to study x-ray and γ-ray background, discrete sources and the study of high-Z elements and nuclei.
A-2	Infrared Astronomical Satellite (IRAS) is to produce an unbiased sky survey in the wavelength region between 8-120 μm.
A-3	Space Telescope is large light-gathering instrument with optical performance near the diffraction limit.
A-4	Cosmic Background Explorer (COBE) will measure the diffuse infrared and microwave emission of the universe.
A-5	Extreme Ultraviolet Explorer objectives are to discover, obtain accurate positions and determine the spectral energy distribution for all detectable EUV sources in the solar neighborhood.
A-6	Shuttle Infrared Telescope Facility (SIRTF) is an astronomical telescope capable of accommodating photometric, spectroscopic, and polarimetric instruments.
A-7	Gamma Ray Observatory (GRO) is to study the most energetic photons originating in our galaxy and beyond.
A-8	Gravity Probe B (GP-B) is to measure relativistic spin-orbit coupling and relativistic spin-spin coupling.
A-9	Advanced X-Ray Astrophysics Facility will serve as an X-ray astrophysics facility to complement visual and radio observations.
A-10	X-Ray Timing Explorer will be devoted to the study of temporal variability in x-ray emitting objects.
A-11	Starlab is a space lab facility for astronomical observations in the visual and ultraviolet portion of the spectrum.
A-12	X-Ray Observatory will make observations with broadband x-ray instruments to resolve fundamental questions in cosmology.
A-13	Cosmic Ray Observatory is to study the composition and energy spectrum of primary cosmic rays.
A-14	Large Area Modular Array of Reflectors is to conduct a full-sky survey for x-ray sources.

Astrophysics Missions (Cont.)

NO.	
A-15	Very Long Base-Line Radio Interferometer will provide maps of compact celestial radio sources.
A-16	Orbiting Submillimeter Telescope can carry out a wide range of astrophysical observations in a spectral region that is not accessible to ground-based observatories because of the absorption by the terrestrial atmosphere.
A-17	Large Ambient Deployable IR Telescope provides improved spatial resolution and energy collecting capability for the study of a wide variety of astrophysical phenomena.

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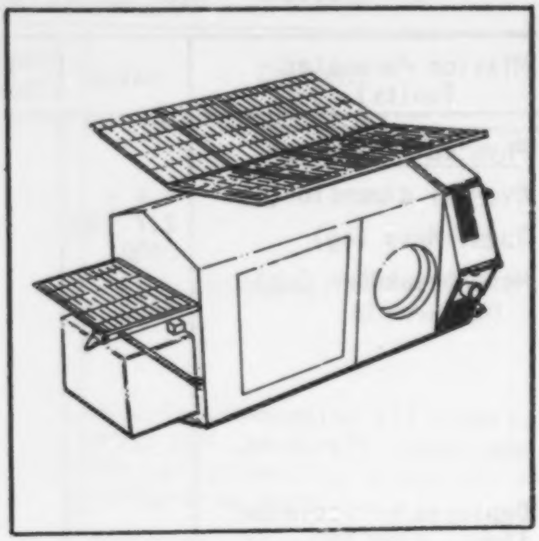
MISSION: HIGH ENERGY ASTRONOMY OBSERVATORY C (HEAO-C) A-1



Status:	Approved
Lifetime:	1 year
Launch and Transfer Vehicles:	Atlas/Centaur
Operational Location:	500 km orbit at 43.6 deg.
Total Mass at Operational Location:	2900 kg.
Average Operational Power:	365 w

OBJECTIVE: Specific scientific objectives of this mission are to: (1) Search for X-ray and gamma ray line emissions in the 0.06 MeV to 10 MeV energy region and measure spectrum, intensity, and isotropy of diffuse cosmic X-ray and gamma ray background; (2) study spectrum, intensity, and temporal fluctuations of discrete cosmic X-ray and gamma ray sources; (3) determine isotopic composition of the most abundant elements from atomic number (Z) from Z=4 (Beryllium) to Z=26 (Iron); and (4) search for super heavy nuclei with charge (Z) greater than 17 thru the trans-uranic elements.

DESCRIPTION: HEAO-C is the last in a series of three satellites. Each of the observatories has a common spacecraft equipment module (SEM) and a mission unique experiment module (EM). The SEM contains all the functional subsystems necessary to operate and control the observatory and experiments. The slowly rotating observatory has the instrumentation generally arranged so that it scans in a direction perpendicular to the axis of rotation, which points toward the Sun. The movement of this axis of rotation as the Earth revolves around the Sun provides the full scan, or survey, of the celestial sphere in a 6-month period. The spacecraft was launched on September 20, 1979 to its intended orbit and was designated HEAO-C. The HEAO program is managed by Marshall Flight Center on behalf of NASA/OSS.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT: High spectral resolution gamma ray spectrometer, isotopic composition of primary cosmic rays and heavy nuclei.

REFERENCES: Mission Operation Report: High Energy Astronomy Observatory HEAO-C, NASA/OSS Report No. S-832-79-03, August 10, 1979

CONTACTS: F. Speer, MSFC, (205) 453-2070

ASTRONOMY

MISSION TECHNOLOGY REQUIREMENTS

MISSION: HIGH ENERGY ASTROPHYSICS OBSERVATORY - C A-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	5.4 x 2.7 (dia)	1	
Total Mass (kg)	2900	1	
Mass breakdown (kg)			
Instruments	1300	1	
Deployed/articulated items, size (m)			
Solar arrays (2)	3.4 x 1.4	1,SOA	
Life			
Flight duration (years)	1	1	
Number of spacecraft	1		HEAO-C is last in a series of 3 similar missions.
Orbit			
Periapse/apoapse altitudes (km)	500	1	Higher inclination selected to observe lower energy cosmic rays.
Inclination (deg)	43.6		

ASTRONOMY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: HIGH ENERGY ASTROPHYSICS OBSERVATORY - C A-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	5×10^8	1	
Storage			
Capacity (bits)	3×10^8	1,SOA	3 tape recorders.
I/O rates (kbps)	6/128		
Spacecraft processors/computers			
I/O rates (kbps)	128	1	Used for commanding all experiments and spacecraft subsystems and for collecting scientific and engineering data.
Memory size (bits)	ND		
Ground Processors/computers			
Memory size (bits)	ND	1	Using data processing center at GSFC.
Communications			
Minimum/maximum downlink rates (kbps)	6/128		S-band link to STDN for real-time/recorded data.
Guidance & Attitude Control			
View direction	Sun		Gyros, sun sensors and star trackers are available sensors. Hydrazine reaction control systems. Spacecraft spins at 0.03 rev/min about axis within 30° of sun. Attitude determined to 0.25 deg. for use in science data reduction.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	NA		
Stability (mrad)	NA		

ASTRONOMY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: HIGH ENERGY ASTROPHYSICS OBSERVATORY - C A-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	365	1,SOA	Power supplied by solar cells; conditioned by shunt regulator; excludes power used directly for battery charging.
Peak power consumed (We)	ND	1	
Power breakdown (We)			
Experiments	120	1	
Spacecraft	245		
Energy Storage			
Storage capacity (J)	6×10^6	1,SOA	Three 20 ampere-hour batteries.
Discharge rate (We)	365	1	
Discharge/recharge times (min)	30/60	1	
Thermal Control			
Component temperature (K)			
Germanium detector	90	1,SOA	Solid CH_4 - NH_3 refrigerator
Electronics	285	1,SOA	Passive means (coatings, insulation, etc.)
Component load (Wt)			
Germanium detector	ND	1	
Electronics	ND	1	

ASTRONOMY
MISSION TECHNOLOGY REQUIREMENTS

MISSION: HIGH ENERGY ASTROPHYSICS OBSERVATORY - C A-1

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	NA		Small hydrazine system used only for attitude control.
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

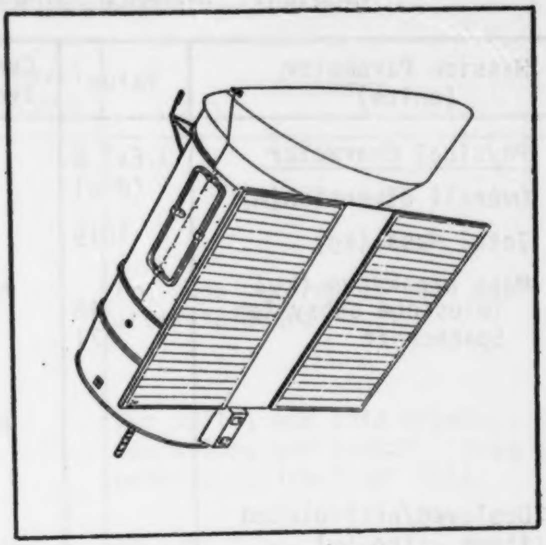
ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS

MISSION: HIGH ENERGY ASTRONOMY OBSERVATORY A-1

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Gamma Ray Spectrometer	Spectrum of gamma ray photons from celestial sources with sensitivity of $10^{-5}(\text{cm}^2\text{sec})^{-1}$	Energy range of 0.06 to 10 MeV (1,SOA); energy resolution of 2.5 keV at 1-3 MeV (1,SOA) Angular resolution is about 30 deg. (1,SOA)	Search for gamma ray line emission due to a variety of phenomena. Four cooled germanium detectors surrounded by CsI (Na) anticoincidence shield (1,SOA) Detectors cooled to 90K by solid CH_4-NH_3 refrigerator (1,SOA).
Isotopic Composition of Cosmic Rays	Flux of primary cosmic rays	Nuclear charge between 4 and 26 (1,SOA); energies between 1 and 15 GeV/nucleon (1,SOA)	Measure isotopic abundances in primary cosmic radiation. Five Cerenkov counters and four hodoscopes (1,SOA) used to determine particle charge, velocity and arrival direction.
Heavy Nuclei	Flux of primary cosmic rays	Nuclear charge range of 17 to 120 (1,SOA); charge resolution of <0.4 (1,SOA); energy range of 0.3 to 10 GeV/nucleon (1,SOA)	Measure elemental composition of heavy nuclei in primary cosmic radiation. Ion chambers and Cerenkov counter used for charge determination (1,SOA).

MISSION: INFRARED ASTRONOMICAL SATELLITE (IRAS) A-2

Status:	Approved
Lifetime:	1 year
Launch and Transfer Vehicles:	Delta 3910
Operational Location:	Polar orbit at 900 km
Total Mass at Operational Location:	1019kg
Average Operational Power:	200



OBJECTIVE: The objective of the Infrared Astronomical Satellite (IRAS) is to produce an unbiased all-sky survey in the wavelength region between 8 and 120 μm. Using a 60 cm diameter helium cooled telescope and detector arrays which are essentially zodiacal light background photon noise limited, heretofore unprecedented sensitivity can be achieved.

DESCRIPTION: The satellite consists of a spacecraft and telescope system. The Netherlands is responsible for the design and manufacture of the spacecraft which supports the telescope system by providing the electrical power, pointing control, computer, data storage and telemetry and the ground operations. The United States is responsible for the telescope system, the processing of the experiment data to produce the final infrared source catalogues, and the Delta launch vehicle. The Jet Propulsion Laboratory manages the project for NASA's Office of Space Science, and is responsible for the End-to-End Information System Design and the data processing. The Ames Research Center is responsible for the design and construction of the telescope system containing the telescope optics, cryogen tank, focal plane detector array, and associated signal processing electronics. The United Kingdom is responsible for providing satellite tracking and other ground support, including the mission control center and "quick-look" data analysis facility. The satellite will be in a twilight sun-synchronous polar orbit at an altitude of approximately 900 km. The launch of IRAS is currently scheduled for early 1981 with a nominal mission lifetime of about one year. A full sky survey is taken in about 100 days.

CRITICAL TECHNOLOGY NEEDS: Infrared detectors, visible aspect sensors, containment of superfluid helium in zero-g environment.

INSTRUMENT OR EXPERIMENT COMPLEMENT: The satellite carries a 60 cm diameter telescope cooled to a temperature of approximately 4K which images the sky on a focal plane containing about 62 detectors cooled to near 2K. The telescope is surrounded by a toroidal cryogen tank containing approximately 600 liters of superfluid helium.

REFERENCES: "Report of the Joint Scientific Mission Definition Team for an Infrared Astronomical Satellite", NASA-TM-79386, May 1976.
"Infrared Astronomical Satellite", Optical Engineering, Nov./Dec. 1977 p.537

CONTACTS: H. H. Aumann, JPL, (213)354-4457

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INFRARED ASTRONOMICAL SATELLITE (IRAS) A-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	3.6x1.6 (dia)	1	
Total Mass (kg)	1019	1	
Mass breakdown (kg)			
Telescope subsystem	748		
Spacecraft	271		
Deployed/articulated items, size (m)			
Telescope cover	0.9(dia)	2, SOA	Cooled cover used to maintain vacuum in telescope is then jettisoned in orbit.
Cryogenic storage(l)	500	1, SOA	Toroidal tank holds superfluid helium at 1.8K.
Life			
Flight duration (days)	365	1, SOA	To meet this requirement, most hardware is fully redundant except battery, momentum wheels, and some power subsystem components.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	900 99	1, SOA	IRAS orbit is Sun-synchronizous with constant solar illumination.
Inclination (deg)			

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INFRARED ASTRONOMICAL SATELLITE (IRAS) A-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	5×10^8	2	
Storage			
Capacity (bits)	4.5×10^8	1, SOA	Two rape recorders; read out after 12 hours.
I/O rates (kbps)	8/1,048		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	1, SOA	Two units, one cold standby, 10^6 operations per second. Used to provide "quick-look" data.
Memory size (bits)			
Ground Processors/ computers			
Memory size (bits)	6.4×10^9	1, SOA	AP 120B Array Processor PDP-11/35 Formatter and online disk. ICL 7040, IBM 360/175 used to establish data base (calibrated fluxes and positions) from raw sensor data.
Time from acquisition to user (hrs)	12		
Communications			
Minimum/maximum downlink rates (kbps)	4-1049	1, SOA	Dedicated IRAS ground station in England receives digital data with 12 m S-band antenna (STDN compatible).
Guidance & Attitude Control			
View direction	Sky-Scan	1, SOA	Sun sensor-star sensor/momentum wheels. Gyros used as sensors during Sun occultations. 30 arc sec. (2σ) pointing determination.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	0.15		
Stability (mrad)	NA		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INFRARED ASTRONOMICAL SATELLITE (IRAS) A-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	200	1, SOA	Photovoltaic
Peak power consumed (We)	364		
Power breakdown (We)			
Spacecraft	148		
Instrument	52		
Energy Storage			
Storage capacity (J)	$7x10^5$		NiCd batteries. 7 Ah capacity; 25% discharge.
Discharge rate (We)	200		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)			
Liquid helium	1.8	1, EV	High efficiency, liquid helium dewar is central to success and duration of the mission.
Radiator	90	1, SOA	
Electronics	295	1, SOA	
Component load (Wt)			
Liquid helium	0.06		
Radiator	ND		
Electronics	200		

ASTROPHYSICS

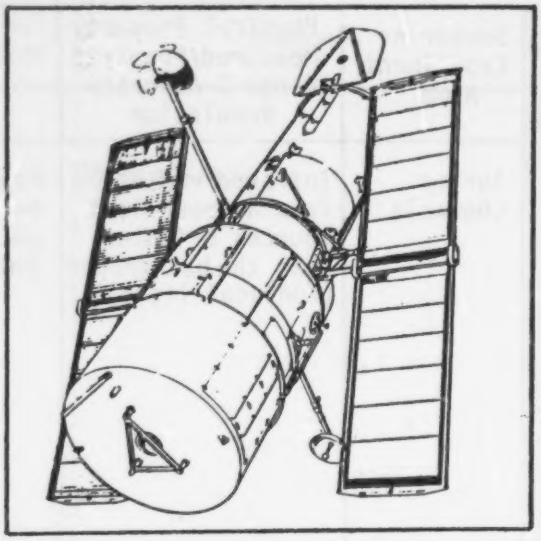
SENSOR/EXPERIMENT PARAMETERS

MISSION: INFRARED ASTRONOMICAL SATELLITE A-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Survey Channels	Infrared radiation from astronomical sources brighter than the background (Zodiacal light)	Five spectral bands are 8-15 μm, 15-30 μm, 30-60 μm, 60-120 μm, and 150-300 μm.	These sensors are used to locate new infrared sources with an overall position uncertainty of about 1/2 arc min. Source temperature is also determined. Numbers of detectors per band are 19, 19, 19, 10 and 2, respectively. Detector materials are Si:As, Si:Tb, Ge:Be, Ge:Ga, and a bolometer, respectively. All are cooled to 2K and arranged within a 30 arc min. field-of-view at the telescope's focal plane.
Low Resolution Spectrometer	Spectrum of infrared radiation	Spectral range of 7 to 21 μm with 4% resolution.	Used in search for broad-band spectral features in stronger discovered sources. Czerny-Turner spectrograph with entrance aperture of 6 x 15 arc min. Multiple detectors (3) for each of 3 spectral orders.

MISSION: SPACE TELESCOPE

Status:	Approved
Lifetime:	15 years to end of useful life
Launch and Transfer Vehicles:	Shuttle with OMS kit
Operational Location:	600 km orbit at 28.8 deg.
Total Mass at Operational Location:	11,070 kg
Average Operational Power:	2.1 kw



OBJECTIVE: The ST is a large light-gathering instrument with optical performance near the diffraction limit. Scientists will be able to observe the universe with a clarity and to distances never before attained. It will be used to attack a wide variety of frontier problems in atmospherics particularly the areas of extragalactic astronomy and observational cosmology.

DESCRIPTION: The optical systems of the NASA Space Telescope consist of a 2.4 meter primary mirror and a 0.3 meter secondary mirror. The Telescope's Ritchey-Chretien optical system will produce an image 1.5 meters behind the front surface of the primary mirror. To achieve the high spatial resolution objective of the ST (10 times better than now possible with ground-based telescopes) will require extremely smooth and precisely shaped mirror surfaces. ST is to be launched in December 1983; it is designed for on-orbit maintenance, (requires astronaut EVA) and for Shuttle recovery and ground refurbishment. Operation of the ST is to be done through the ST Science Institute and an ST Operations Control Center. ESA is providing the photovoltaic power source and the Faint Object Camera and is participating in the observing program.

CRITICAL TECHNOLOGY NEEDS: The ST program has made significant technical advances in the state-of-the-art in the areas of mirrors, pointing systems, detectors and on-orbit repair/changeouts.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Wide field/planetary camera, faint object camera, faint object spectrograph, high resolution spectrograph and high speed photometer. Fine guidance system also used for astrometry.

REFERENCES: M. S. Longair and J. W. Walker, editors, "Science Research with the Space Telescope", Proceedings of IAU Colloquium No. 54, NASA CP-2111, 1980.
D. S. Leckrone, "Space Telescope Science Instruments", SPIE Vol. 183 Space Optics, 1979.

CONTACTS: F. A. Speer, MSFC, (205)453-2039
C.R. O'Dell, MSFC, (205)453-3033

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE TELESCOPE A-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	13.6 x 4.3 (dia)	1, SOA	
Total Mass (kg)	11,070	1	
Mass breakdown (kg)			
Science Instruments	1550		
Optical Telescope Asy.	4000		
Support Sys. Module	4600		
Solar Array	300		
Reserve	620		
Deployed/articulated items, size (m)			
Solar Arrays(2)	3.0x12.7	1, SOA	
High Gain Antennas(2)	1.05(dia)	1, SOA	On 3.9 m boom.
Aperture cover	3x3	1, SOA	
Life			
Flight duration (yrs)	5	1, SOA	15 year useful lifetime is accomplished with on-orbit repair capability and Shuttle re-boost to a higher orbit. ST can be recovered for refurbishment.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	600	1, SOA	
Inclination (deg)	28.8		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE TELESCOPE A-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^{10}	1, SOA	
Storage			
Capacity (bits)	3x10^{9}	1, SOA	Tape recorders (3)
I/O rates (kbps)	4-1024		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	1, SOA	Microprocessors in instruments, DF224 computer performing 350K operations/sec.
Memory size (bits)	24K		
Ground Processors/ computers			
Memory size (bits)	ND	2, SOA	Functions split between Science Institute and ST Operations Control Center.
Communications			
Minimum/maximum downlink rates (kbps)	4-1024	1, SOA	Digital science and engineering data sent in real-time or from recorders; high rate uses TDRSS S-band single access service and ST high gain antenna. TDRSS multiple access and STDN capabilities also available.
Guidance & Attitude Control			Sensors: Fine guidance sensor, rate gyro assembly, fixed head star tracker magnetometer, digital Sun sensor. Actuator: Reaction wheel assembly, magnetic torquers. Star sensors and gyros provide a pointing accuracy of about 1 mrad which is needed to place desired guide star in field of fine guidance sensor. The later sensor then provides error signals to achieve stated stability (0.007 arc sec) and to measure relative position to 10^{-6} mrad (0.002 arc sec).
View direction	Total Sky	1, SOA	
Position accuracy (km)	NA		
Pointing accuracy (mrad)	1.0		
Stability (mrad)	3x10^{-5}		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE TELESCOPE A-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	2,109	1, SOA	ESA supplies photovoltaic arrays with raw output of 4000 w. Generally constant loading.
Peak power consumed (We)	2,367		
Power breakdown (We)			
Science Instruments	470		
Support Sys. Module	820		
Optical Telescope Asy.	560		
Energy Storage			
Storage capacity (J)	$6x10^6$	1, SOA	60 Amp Hr NiCd batteries. Discharge to 50% of rated capacity; 15,000 cycles. Replaced during on-orbit servicing.
Discharge rate (We)	2100		
Discharge/recharge times (min)	30/61		
Thermal Control			
Component temperature (K)			
Optical Telescope Asy.	295	1, SOA	The ST thermal design provides stable thermal environment for the OTA. The ST thermal control is passive, accomplished by use of paints, coatings, multi-layer insulation, and thermostatically controlled heaters. The most significant coating is a flexible optical solar reflector (FOSR--teflon metalized backside) used on the outer surface of the ST to cold bias the ST to be insensitive to variations in external solar flux.
CCD Sensors	178		
Component load (Wt)			
OTA	<445	1	
CCD Sensors	ND		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE TELESCOPE A-3

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	NA	3	Shuttle can be used to raise orbit altitude during revisit, if necessary, to prevent orbit decay below critical altitude before next planned revisit/ recovery.
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS

MISSION: SPACE TELESCOPE A-3

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Wide Field/ Planetary Camera	Spatial distribution of brightness of astronomical objects for visual magnitudes between 7.5 and 27 with up to 1% photometric accuracy	Spectral range of 115 to 1100 nm; field of view is 1.1 arc min or 2.7 arc min, with a resolution of about 0.1 arc sec (sensor limited) (1,EV)	Used to map galaxies, nebulae, planets, etc. with high photometric and geometric accuracy. Primary instrument in red and near-infrared. Filters, polarizers, prisms used to define photometric response. CCD array sensors with 800 x 800 format. (1,EV)
Faint Object Camera	Spatial distribution of brightness for objects with $21<V<28$ with at least 2% photometric accuracy	Spectral range of 115 to 600 nm; field of view is 11 or 22 arc sec with angular resolution of about 0.1 arc sec (telescope limited) (1,SOA)	Detection of faint object and imagery of quasars, faint galaxies, etc. Primary instrument in blue and UV. Filters, polarizers, dispersive elements used. Sensor is intensified vidicon which counts individual photons in a 512x512 format. (1,EV)
Faint Object Spectrograph	Emission/absorption line strengths in faint objects (to 26th magnitude) with at least 1% photometric accuracy	Spectral range of 115 to 700 nm with spectral resolutions of 10^{-2} and 10^{-3}. Entrance apertures of 0.1 to 4.3 arc sec. Time resolution of 0.01 sec. (1,SOA)	Used to observe spectrum from faint stars, galaxies, etc. Multiple dispersive elements. Single photon counting detectors with 512 channels and low background (Digicon)(1,EV)
High Resolution Spectrograph	Emission/absorption strengths to 17th magnitude and 1% photometric accuracy	Spectral range of 107 to 320 nm with resolutions of 10^{-3} to 10^{-5}. Entrance apertures of 0.2 and 2.0 arc sec. (1,SOA)	High resolution UV spectroscopy of relatively bright stars, nebulae, planets, etc. Multiple dispersive elements. 512 channel photon counting detector with low background (Digicon). (1,EV)
High Speed Photometer	Integrated flux to 24th magnitude and 0.2% photometric accuracy	Spectral range of 120 to 900 nm subdivided by filters. Entrance apertures of 0.4 to 10 arc sec. Time resolution of 16 μsec and accuracy of 10 msec. (1,SOA)	Used to measure absolute brightness and time variations of point sources. Photomultiplier and four image disectors used as detectors (1000 filter/ aperture combinations). (1,SOA)

ASTROPHYSICS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Status: Approved

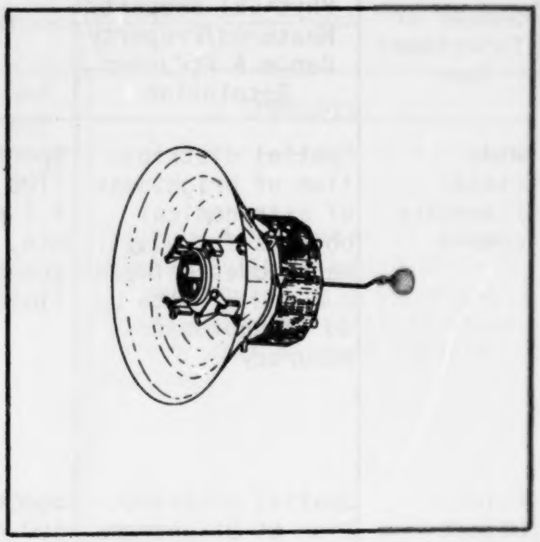
Lifetime: 1 year

Launch and Transfer Vehicles: Shuttle

Operational Location: Polar orbit at 900 km

Total Mass at Operational Location: 1200kg

Average Operational Power: 250 w



OBJECTIVE: The Cosmic Background Explorer (COBE) will measure the diffuse infrared and microwave emission of the universe, from 1 micron to 13 mm. The radiation comes from the primeval "big bang", the earliest galaxies, interplanetary and interstellar dust, and infrared galaxies. The spectrum and angular distribution are determined with orders of magnitude improvement in sensitivity and accuracy compared to other previous methods.

DESCRIPTION: The COBE mission is a planned FY 81 new start for NASA's Astrophysics Program. Launch by the Shuttle would take place in 1985 from Vandenburg Air Force Base. The spacecraft has a propulsion system for transfer from the Shuttle orbit to the desired altitude. The infrared experiments would make use of the cryogenically cooled detector technology from the Infrared Astronomy Satellite (IRAS). The spacecraft spins at 1 RPM about an axis which points to the Earth nadir. The instruments look at deep space in the anti-Earth direction. A full sky survey is obtained in about 100 days; nominal mission duration is one year.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Far infrared absolute spectrophotometers, diffuse infrared background experiment and differential microwave radiometer.

REFERENCES: "Preliminary Execution Phase Project Plan for Cosmic Background Explorer (COBE)", NASA/GSFC, January 1979.

CONTACTS: J.C. Mather, GSFC, (301)344-8720
S.J. Paddack, GSFC, (301)344-7751

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4.8x4.4	2, SOA	
Total Mass (kg)	1421	2, SOA	
Mass breakdown (kg)			
Instruments & Elect.	160		
Dewar Assy	524		
Spacecraft Subsystems	85		
Solar Array	46		
Propulsion System	273		
Structures	333		
Deployed/articulated items, size (m)			
Antenna Mast	2.7	2, SOA	0.8(dia) antenna deployed after final orbit.
Life			
Flight duration (days)	365	1, SOA	Limited by stored cryogen life time. DMR instrument would still run beyond 1 year.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	900	2, SOA	Sun-synchronous with constant solar illumination.
Inclination (deg)	99		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	2, SOA	
Storage			
Capacity (bits)	ND	2, SOA	NASA standard tape recorder or bubble memory.
I/O rates (kbps)	4-640		
Spacecraft processors/ computers			One instrument has microprocessor for data compression. It has 2K x 8-bit storage. All science and engineering data go through analog/digital multiplexer to data storage/telemetry systems.
I/O rates (kbps)	NA	2, SOA	
Memory size (bits)			
Ground Processors/ computers			
Memory size (bits)	ND	2, SOA	32-bit minicomputer with array processor to perform attitude determination and data analysis algorithms--investigators interface with it via dedicated remote terminals.
Communications			
Minimum/maximum downlink rates (kbps)	8	2, SOA	Real-time or real-time plus recorded digital data using TDRSS S-band multiple access service.
Guidance & Attitude Control			
View direction	Anti-nadir	2, SOA	Sun and Earth horizon sensor inputs to analog system controlling reaction wheels. Magnetometers and magnetic torquers for reaction wheel unloading. 3-axis attitude control (to 1 deg) with optical axis rotating at 1 RPM, normal to Sun and anti-nadir pointing.
Position accuracy (km)	1	2	
Pointing accuracy (mrad)	4	2, SOA	
Stability (mrad)	NA	2	

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	224	3, SOA	Power generated by the solar cells will be supplied directly to the spacecraft through a regulated 28 volt bus.
Peak power consumed (We)	ND		
Power breakdown (We)			
Attitude Control	40		
Experiments	120		
Energy Storage			
Storage capacity (J)	9×10^5	3, SOA	COBE orbit will provide continuous sunlight for the spacecraft for the first 10 months; 9 AH NiCd batteries are available.
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)			
Infrared Instruments	2	2, SOA	Liquid helium dewar used to cool IR systems for low background, high sensitivity. Microwave experiment requires careful temperature control of internal/external calibrators and horn antennas.
Other Electronics	295	2, SOA	
Component load (Wt)			
Infrared Instruments	ND	2	
Other Electronics	ND	2	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	2, SOA	Hydrazine system used to attain circular orbit at 900 km. Mission requirements depend on Shuttle orbit used for deployment, but are SOA in any case.
Thrust level(N)	ND		
Isp(sec)	240		
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: COSMIC BACKGROUND EXPLORER (COBE) A-4

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Far Infrared Absolute Spectrophotometer	Spectrum and angular distribution of far IR background radiation with sensitivity of 10^{-14} w/cm^2/sr.	Spectral range of 0.1 to 1.0 mm with 5% resolution (2,SOA). Field-of-view is 7 deg.	Detection of early universe and interstellar dust. Cryogenic Michelson interferometer with optics diameter of 0.3m (2,SOA).
Diffuse Infrared Background Experiment	Brightness and angular distribution of IR sky background with sensitivity of 10^{-13}w/cm^2/sr.	Spectral range of 1 to 300 μm with broadband filters defining pass bands (2,SOA). Field-of-view is 1 deg.	See evidence of primeval galaxies, interstellar and interplanetary dust. Cooled photoconductor and bolometer detectors covering specific spectral bands (2,SOA) Optics diameter of 0.2m.
Differential Microwave Radiometers	Brightness of microwave background radiation with 0.0003K sensitivity	Four 1 GHz bands in the 20-90 GHz frequency range (2,SOA). Field-of-view is 7 deg.	Detect anisotropy in the early universe. Separate antennas, radiometers for each frequency; Very accurate and stable internal/external calibrations. (2,SOA). Each antenna has aperture of about 10 wavelengths and low sidelobes.

ASTROPHYSICS

MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Status: Planned

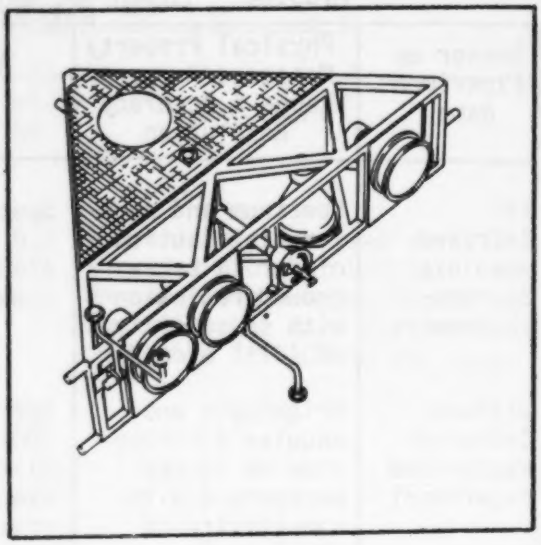
Lifetime: 1 year

Launch and Transfer Vehicles: Shuttle

Operational Location: 550 km orbit at 28.5 deg.

Total Mass at Operational Location: 400 kg

Average Operational Power: 70 w



OBJECTIVE: The objectives of the Extreme Ultraviolet Explorer (EUVE) mission are to discover, obtain accurate positions and determine the spectral energy distribution for all detectable EUV sources in the solar neighborhood. These data are used to check and refine theories for the late stages of stellar evolution and to analyze the effects of EUV radiation on the interstellar medium.

DESCRIPTION: The spacecraft is designed to spin about the sun line. The instruments take data in the Earth's shadow. Three EUV telescopes with different filters are mounted perpendicular to the spin axis so that they observe a great circle on the celestial sphere during each rotation. Over one year, the entire sky is examined twice. A single multifilter telescope examines an area within 5 deg. of the celestial equator with about 100 times greater sensitivity.

CRITICAL TECHNOLOGY NEEDS: None. Instrument development effort is complete.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Extreme ultraviolet full sky survey.

REFERENCES: Astrophysics Mission Concept-
Extreme Ultraviolet Explorer, NASA/OSS, February 1980.

CONTACTS: S. E. Willis, GSFC, (301) 344-8566

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4.5	2	Shape minimizes Shuttle payload charges.
Total Mass (kg)	400	2	
Mass breakdown (kg)			Mass is not critical and considerable growth can be permitted.
Experiments	114	2	
Spacecraft	211	2	
Propulsion	75	2	
Deployed/articulated items, size (m)	NA		
Life			
Flight duration (years)	1	2,SOA	Spacecraft designed for Shuttle retrieval in the event of a failure or at the end of the mission.
Number of spacecraft	1	2	
Orbit			
Periapse/apoapse altitudes (km)	550	2	Shuttle deployment altitude is 300 km; small propulsion system used to raise orbit to 550 km and to lower it for Shuttle retrieval.
Inclination (deg)	28.5	2	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^8	2,SOA	
Storage			
Capacity (bits)	2×10^8	2,SOA	Two NASA Standard tape recorders.
I/O rates (kbps)	3.2	2,SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	3.2	2,SOA	
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	2	Use a multi satellite operation control center.
Communications			
Minimum/maximum downlink rates (kbps)	3.2	2,SOA	Use TDRSS S-band multiple access service; signal transmitted via a 4.7 dB antenna when TDRSS is within 45 days of spin axis.
Guidance & Attitude Control			
View direction	Sun	2	Spacecraft spins at 1.5±0.2 rpm about axis pointing at sun. Spin axis controlled to 50 mrad (± 3 deg.). Sun sensors, magnetometers and two 10^5 pole-cm electromagnets used for open loop (via ground) control of spin axis and rate. Star sensor provides 0.3 mrad attitude knowledge.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	50	2,SOA	
Stability (mrad)	NA		

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	70	2,SOA	Solar cell array ($2.2 m^2$) on side facing sun.
Peak power consumed (We)	110	2	
Power breakdown (We)			
Instruments	36	2	
Spacecraft	76	2	
Energy Storage			
Storage capacity (J)	9×10^5	2,SOA	9 Ampere-hour battery.
Discharge rate (We)	110	2	Instruments operate only at night.
Discharge/recharge times (min)	30/60	2	
Thermal Control			
Component temperature (K)			
Electronics, propellents	295	2,SOA	Blankets and coatings used to control temperature to within 10 K of nominal.
Component load (Wt)			
Electronics, propellents	ND	2	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

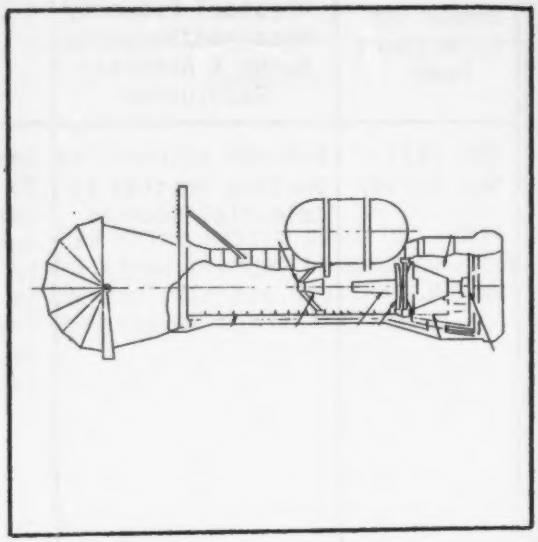
MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	280	2,SOA	Hydrazine system used for orbit altitude changes between Shuttle deploy/retrieve orbit at 300 km and operations at 550 km.
Thrust level(N)	ND		
Isp(sec)	225		
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS
MISSION: EXTREME ULTRAVIOLET EXPLORER A-5

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
EUV Full Sky Survey	Extreme ultraviolet photons emitted by celestial sources	Spectral range of 7.5 to 53 nm (1, SOA), split into three broad wavelength bands: 7.5 to 18 nm, 16 to 32 nm and 39 to 53 nm (1,SOA) Field of view is 6 x 6 deg. with angular resolution of 6 arc min (1,SOA)	Use to identify, study sources in EUV, such as nuclei of planetary nebulae, white dwarfs, neutron stars. Four Wolter-Schwarzschild Type I telescopes with collecting area of 700 cm^2 and focal length of 50 cm. (1,SOA). Three telescopes have single broad band filter; fourth has interchangeable filters; filters are thin films of plastic or metal (1,SOA). Detectors are microchannel plates coupled to resistive anode image converters (RANICON) (1,SOA).

MISSION: SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) A-6



Status:	Planned
Lifetime:	6 years useful life
Launch and Transfer Vehicles:	Shuttle/Spacelab
Operational Location:	400 km orbit at about 45 deg.
Total Mass at Operational Location:	2950kg for 14 day mission
Average Operational Power:	400 w

OBJECTIVE: The Shuttle Infrared Telescope Facility (SIRTF) is an astromomical telescope capable of accommodating photometric, spectroscopic and polarimetric instruments. SIRTF has 100 to 1000 times more sensitivity in the 2μm to 1 mm spectral range than any existing IR telescope. Typical studies include the cold regions of space where dust and gas are condensing into stars, solar system objects (e.g., asteroids) and IR emitting extragalatic objects.

DESCRIPTION: SIRTF is a cryogenically cooled infrared telescope with a 0.85 m entrance aperture. It is designed for use as a Shuttle/Spacelab payload with pointing provided by the ESA Instrument Pointing System (IPS). SIRTF is supported by Shuttle systems and by the Spacelab igloo and two pallets. Up to six instruments can be accommodated in the cooled Multiple Instrument Chamber (MIC). A movable beamsplitter directs the IR energy to one instrument at a time and passes a visible beam to the fine guidance sensor. SIRTF is operated by the payload specialist from the Shuttle aft flight deck who is in contact with ground controllers and scientists. The nominal SIRTF mission uses the first day for reaching thermal equilibrium and the remainder of a 14 day period for astronomical observations. A new project start in FY 81 is being considered by NASA's Astrophysics Programs with first flight planned for 1986.

CRITICAL TECHNOLOGY NEEDS: SIRTF requires careful control of contamination from the Shuttle and itself.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Two to six instruments per mission selected from following types: spectrometers, photometers, and cameras.

REFERENCES: "SIRTF System Design Summary Document", Perkin-Elmer Corp., (ER-399) for NASA/Ames Research Center, August, 1979.

CONTACTS: L. Young, ARC, (415) 965-6546

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) A-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	8.7x3.1 (dia)	2, SOA	SIRTF only. Dust and aperture covers open in orbit. Entire telescope is vacuum sealed for launch and is pointed by the spacelab IPS at the desired astronomical objects.
Total Mass (kg)	2,950	2	SIRTF mass for 14 day mission; total Shuttle payload including Spacelab hardware, energy kits, etc. is 10,472 kg.
Mass breakdown (kg)			
Structure	1673		
Tanks, crypgen	454		
Multiple Inst. Chamber	384		
Optics	85		
Thermal Control	35		
Miscellaneous	321		
Deployed/articulated items, size (m)			
Dust cover	2.6 (dia)	2	
Aperture Cover	1.2 (dia)	2	
Life			
Flight duration (days)	7-30	2, SOA	Individual missions are flown at about 1 year intervals. SIRTF is refurbished after each flight over a useful life of about 6 years.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	400	2	NOTE: SIRTF not allowed to point within 45° of any hot object such as Sun, Earth, Shuttle.
Inclination (deg)			

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) A-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	2	
Storage Capacity (bits) I/O rates (kbps)	NA		SIRTF will use Shuttle/Spacelab systems for command and data handling. Spacelab has low and high rate analog/digital inputs to multiplexers and analog/video and digital tape recorders. A dedicated microprocessor is needed for motion compensation and fine pointing control. Payload Operations Control Center and Mission Control Center participate in generating commands and demultiplexing, displaying and recording data for experiments.
Spacecraft processors/ computers I/O rates (kbps) Memory size (bits)	NA		
Ground Processors/ computers Memory size (bits)	ND		
Communications			
Minimum/maximum downlink rates (kbps)	NA	2, SOA	Use Shuttle capabilities; S-and K_u-band links for digital and analog/video data and voice communications through TDRSS at high rates.
Guidance & Attitude Control			
View direction	Total Sky	2, SOA	Guidance and control provided by Shuttle systems. Pointing by the Spacelab IPS with assistance from SIRTF image motion compensation and fine pointing systems (fine guidance sensor, computer and articulated secondary mirror) IPS gyros and startrackers are mounted on SIRTF. Use quasi-inertial attitudes for orbiter to reduce effects of using reaction control system.
Position accuracy (km)	ND	2	
Pointing accuracy (mrad)	5×10^{-3}		
Stability (mrad)	5×10^{-4}		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF) A-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	400	2, SOA	Provided by Shuttle via Spacelab and IPS interface.
Peak power consumed (We)	ND		
Power breakdown (We)			
Experiments	300		
Other	100		
Energy Storage	NA		
Storage capacity (J)			
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
IR telescope	10-20	2, SOA	Liquid helium stored in a 1300 l. external tank is used to cool the IR telescope including the instruments. Detectors are cooled by a separate dewar of superfluid liquid helium.
IR detectors	2		
Component load (Wt)			
IR telescope	1-10	2	
IR detectors	0.1	2	

ASTROPHYSICS

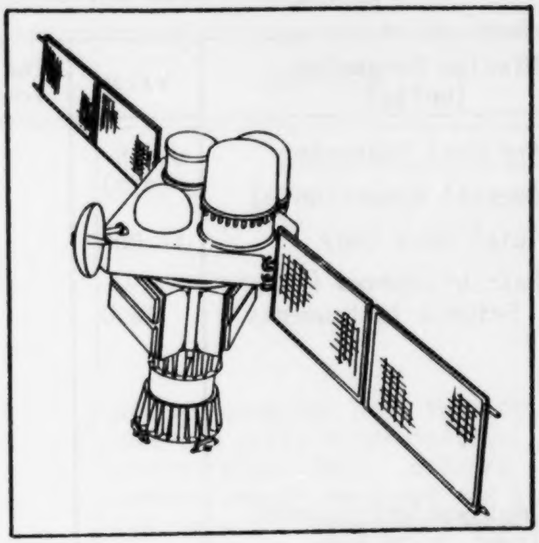
SENSOR/EXPERIMENT PARAMETERS

MISSION: SHUTTLE INFRARED TELESCOPE FACILITY A-6

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Not Determined (2 to 6 instruments accommodated on each SIRTF flight)	Infrared emission from astronomical objects (background limited at a noise equivalent power (NEP) of 10^{-17} w/Hz $^{1/2}$	May use any portion of the SIRTF spectral range of 2 μm to 1 mm. Angular resolution is diffraction limited for wavelengths >5μm. Usable field-of-view is at least 7 arc min. SIRTF provides beam chopping with variable amplitude (3 arc sec to 3 arc min) at a freqeuncy of about 10Hz.	Up to six instruments to be accommodated in the Multiple Instrument Chamber which has dimensions of 1 m x 1 m (dia.) Telescope collected IR energy is directed to one instrument at a time. Instruments are cooled to <10K; detectors can be cooled to <2K.

MISSION: GAMMA RAY OBSERVATORY (GRO) A-7

Status:	Planned
Lifetime:	2 years in orbit
Launch and Transfer Vehicles:	Shuttle
Operational Location:	400 km orbit at 28.5 deg.
Total Mass at Operational Location:	11,000 kg.
Average Operational Power:	2,000 w



OBJECTIVE: The objective of the GRO is the study of the most energetic photons originating in our galaxy and beyond. These photons provide the most direct means of studying the largest transfers of energy occurring in astrophysical processes.

DESCRIPTION: The GRO will carry five large instruments into a 400 km circular orbit for an observation period of 2 years. The GRO will be launched from the ETR by a Shuttle and supported by the TDRSS. A mission contractor will be chosen to develop the space segment (observatory) and the ground segment. Consequently, detailed information is not available on many subsystem parameters. The scientific instruments, developed by principal investigators at various institutions, will be GFE to the mission contractor. The instruments are expected to pace the system development. Launch is expected the last quarter of CY 85 assuming a new project start in FY 81. Phase B studies are planned for 1980.

CRITICAL TECHNOLOGY NEEDS: Instrument development; solid state memories; onboard orbit, attitude and time determination.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Gamma ray spectroscopy experiment, scintillation spectrometer, imaging Compton telescope, gamma ray telescope, burst and transient source experiment.

REFERENCES:

CONTACTS: J.A. Hrastar, GSFC, (301)344-8857
D. Kniffen, GSFC, (301)344-6617

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GAMMA RAY OBSERVATORY (GRO) A-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	6x4.5 (dia)	3	The Phase B study by potential mission contractors is about to start. More definite values of parameters will be available at the completion of the study. All parameters listed prior to the completion of the study are estimates.
Total Mass (kg)	11,000	3	
Mass breakdown (kg)			
Science Instruments	6600	3	
Deployed/articulated items, size (m)			
Solar Array	ND	3	
TDRS Antenna	ND	3	
Life			
Flight duration (days)	730	3, SOA	
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	400	3, SOA	
Inclination (deg)	28.5		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GAMMA RAY OBSERVATORY (GRO) A-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	$3 \cdot 10^9$	3	
Storage			
Capacity (bits)	10^8-10^9	3, SOA	Tape recorder
I/O rates (kbps)	32		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, EV	Onboard computer used for attitude and orbit determination, control algorithms. Onboard command memory required for all instruments. Onboard maintenance of universal time required to 0.1 msec. Gamma ray burst data desired in real-time.
Memory size (bits)			
Ground Processors/ computers			
Memory size (bits)	ND	3	
Communications			
Minimum/maximum downlink rates (kbps)	32	3, SOA	Real-time digital data via TDRSS S-band multiple access link. Recorded data via same link or at higher rate via S-band single access link.
Guidance & Attitude Control			
View direction	Any	3, SOA	
Position accuracy (km)	ND		
Pointing accuracy (mrad)	9	3, SOA	GRO is 3-axis stabilized; will point at a celestial target for days or weeks. Sensors/actuators are not determined. One experiment (EGRET) requires attitude determination to 2 arc min. (0.6 mrad). It is desired that attitude determination and universal time to 0.1 ms be provided by onboard systems.
Stability (mrad)	ND	3	

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GAMMA RAY OVSERVATORY (GRO) A-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	2,000	3, SOA	Power provided by solar cells; includes battery charging power.
Peak power consumed (We)	2,000		
Power breakdown (We)			
Scientific Instrument	480		Instruments contain photomultiplier tubes and spark chambers which require high voltages.
Battery charging	ND		
Thermal control	ND		
Spacecraft subsystems	ND		
Energy Storage			
Storage capacity (J)	ND	3, SOA	
Discharge rate (We)	ND	3, SOA	Batteries
Discharge/recharge times (min)	ND	3, SOA	
Thermal Control			
Component temperature (K)			
GRSE Cryostat	ND	3	Thermal control needed for instruments, particularly GRSE's cooled detector. Methods not determined.
Other instruments, electronics	ND		
Component load (Wt)			
GRSE Cryostat	ND		
Other	ND		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GAMMA RAY OBSERVATORY (GRO) A-7

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3	The GRO will be launched by Shuttle to operating orbit. Propulsion needed for controlled re-entry if Shuttle does not retrieve.
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

ASTROPHYSICS

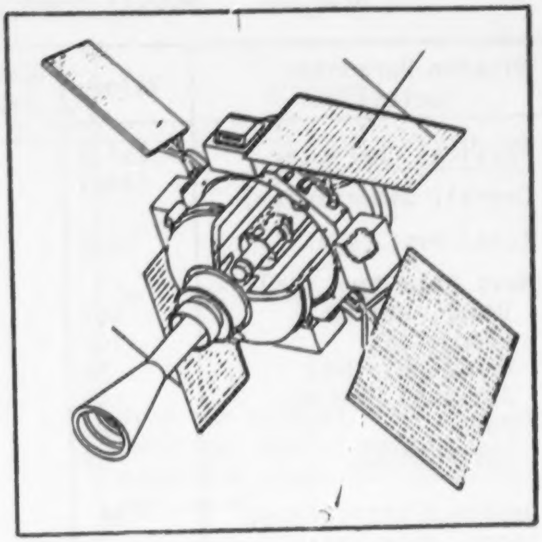
SENSOR/EXPERIMENT PARAMETERS

MISSION: GAMMA RAY OBSERVATORY (GRO) A-7

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Gamma Ray Spectroscopy Experiment (GRSE)	Gamma ray photons with sensitivity of 10^{-5}/cm^2/sec for line emission	Energy range of 0.03 to 10 MeV with resolution of about 2keV (3,SOA). Field-of-view of about 40 deg. Time resolution of 1 ms.	High spectral resolution studies of discrete, extended and diffuse gamma ray sources. Cooled germanium detector, (60-80K) aperture defined by rotating modulator; active anticoincidence shield (3,SOA).
Gamma Ray Observatory Scintillation Spectrometer (GROSS)	Gamma ray photons with sensitivity of 10^{-5}/cm^2/sec for line emissions	Energy range of 0.1 to 10 MeV with 3-8% resolution (3,SOA). Field-of-view of about 9 deg.	Comprehensive observations using scanning/offset pointing. Large NaI crystal detectors (4 units) (3,SOA).
Imaging Compton Telescope (COMPTEL)	Gamma ray photons with sensitivity of 10^{-6}/cm^2/sec for line emission	Energy range of 1 to 30 MeV with 10% resolution (3,SOA). Field-of-view about 60 deg.; angular resolution of 2 to 6 deg.	Sensitive survey and studies of gamma ray sources. Compton scattering observed between upper NE213 liquid scintillator and lower NaI crystal (3,SOA).
High Energy Gamma Ray Telescope (EGRET)	Gamma ray photon with sensitivity of 10^{-8}/cm^2/sec for point sources	Energy range of 20 MeV to 30 GeV with resolution of 15% above 100 MeV. (3,SOA). Timing accuracy of 0.1 ms. Angular resolution for point sources is about 5 arc min.	Studies of high energy gamma rays including position determinations for point sources. Spark chambers and NaI scintillator arrays to determine arrival direction and energy of photons; anticoincidence shield (3,SOA).
Burst and Transient Source Experiment (BATSE)	Gamma ray photons with sensitivity of 6×10^{-8}/erg/cm^2 for 10 sec burst	Energy range of 50 to 600 KeV(3,SOA) Source location accuracy of 1/2 to 2 deg. Time resolution of 0.1 ms.	Monitor sky for gamma ray bursts; locate and study transients. Six NaI crystal detectors with anticoincidence shields(3,SOA

MISSION: GRAVITY PROBE - B (GP-B) A-8

Status:	Planned
Lifetime:	1 year in orbit
Launch and Transfer Vehicles:	Shuttle plus OMS kit
Operational Location:	True polar orbit at 520 km
Total Mass at Operational Location:	1270 kg
Average Operational Power:	225 w



OBJECTIVE: The objective of the Gravity Probe-B mission is to measure the goedetic precession due to the motion of a gyroscope through a gravitational field (relativistic spin-orbit coupling) and the precession produced by the twisting of space due to the rotation of the Earth itself (relativistic spin-spin coupling). High precision measurement of the magnitude of these two effects will constitute a fundamental step in discriminating between viable competing theories of gravitation. Measurements with the necessary precision can only be made in the space environment.

DESCRIPTION: This mission concept was first proposed in 1962. A technology program supported by NASA's Astrophysics Program began in 1962 at both Stanford University and NASA/MSFC. The experiment and mission are unique. Current plans call for a FY 82 new project start leading to launch by Shuttle into a true polar orbit in 1985. In orbit the spacecraft acquires the guide star Rigel, which is in the orbit plane, and tracks it for the entire 1 year mission.

CRITICAL TECHNOLOGY NEEDS: Ultra precision in the manufacture of gyro rotors and housings; non-contact methods of suspending and measuring gyros positions; squid magnetometers; ultra low, ultra stable magnetic field region.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Four gyroscopes, each a perfect quartz sphere inside a superconducting magnetic shield, and an all quartz telescope.

REFERENCES: "To Perform a Gyro Test of General Relativity in a Satellite", Final Report for NASA Grant No. 05-020-019.
"Mission Definition for a Relativity Explorer for the Stanford University Experiment", Ball Brothers Research Corp., Report F75-12, October 1975.

CONTACTS: R.A. Potter, MSFC, (205)453-3430
C.W.F. Everitt, Stanford University (415)497-1389

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GRAVITY PROBE - B (GPB) A-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4.2x4.2 (dia)	2, EV	
Total Mass (kg)	1270	2	
Mass breakdown (kg)			
Dewar, helium	562		
Propulsion	102		
Commands, data	56		
Attitude Control	43		
Power	124		Includes solar arrays.
Instruments	89		
Deployed/articulated items, size (m)	NA	2	Solar panels, antennas, are fixed.
Life			
Flight duration (days)	365	2, SOA	Helium supply provided for 365 days as design lifetime. Shorter duration will result in degraded data.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	520	2, SOA	Guide star, Rigel, in orbit plane.
Inclination (deg)	90		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GRAVITY PROBE - B (GP-B) A-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	$2.2\text{x}10^7$	2, SOA	
Storage			
Capacity (bits)	$5\text{x}10^5$	2, SOA	Solid state memory.
I/O rates (kbps)	<1	2, SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	ND		Used for subsystem control, data handling; NSSC-1 computer executing about 10^5 operations per second.
Memory size (bits)	$1\text{x}10^6$		
Ground Processors/ computers			
Memory size (bits)	$8\text{x}10^9$	2	
Communications			
Minimum/maximum downlink rates (kbps)	.25-.51	2, SOA	TRDSS S-band multiple access service used for digital data.
Guidance & Attitude Control			
View direction	Rigel	2, EV	Four gyroscopes are aligned with spin axes parallel to the guide star (Rigel) line-of-sight. Gyro precession is compared to star tracker reference. Helium boil-off is used with proportional thrusters for spacecraft attitude and position control in 6 axes. Spacecraft rotates about star line-of-sight at approximately one revolution per 15 minutes.
Position accuracy (km)	NA	3	
Pointing accuracy (mrad)	$5\text{x}10^{-6}$	3, EV	
Stability (mrad)	$1\text{x}10^{-4}$	3, EV	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GRAVITY PROBE - B (GP-B) A-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	224	2, SOA	Solar array-4 paddles with cells on each side of honeycomb structure. Paddles are radialy mounted within the Shuttle cargo bay and require no deployment in orbit.
Peak power consumed (We)	270		
Power breakdown (We)			
Command, data	105		
Attitude Control	43		
Experiment	76		
Energy Storage			
Storage capacity (J)	$2x10^6$		
Discharge rate (We)	284	2, SOA	Three 6 Ah NiCd batteries, 25% maximum discharge.
Discharge/recharge times (min)	30/70		
Thermal Control			
Component temperature (K)			
Experiment	1.6	2, EV	The GP-B experiment consisting of a quartz block containing gyros, telescope, and proof mass is maintained within a dewar at approximately 1.6K with a stability of <0.02 mK.
Dewar Surface	220	2, SOA	
Spacecraft	285	2, SOA	
Component load (Wt)			
Experiment	ND	2, SOA	
Dewar Surface	ND		
Spacecraft	ND		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: GRAVITY PROBE - B A-8

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion	NA		See Guidance and Attitude Control.
Total ΔV required (m/sec)			
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: GRAVITY PROBE - B A-8

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Orbiting Gyroscope Experiment	Relativistic precession of a gyroscope due to its orbital motion about a massive body-Earth	Range for Geodetic precession is 7 arc sec per year, motional effect is 0.05 arc sec per year. Resolution needed is 0.001 arc sec per year (2,EV)	Tests relativity theory. Gyro precession measured relative to position of the star Rigel. Experiment requires low temperature (1-6K), stable temperature (<0.2 mK), low gravity ($<10^{-10}$g) and low magnetic fields achieved with superconducting shield (2,EV).

ASTROPHYSICS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Status: Planned

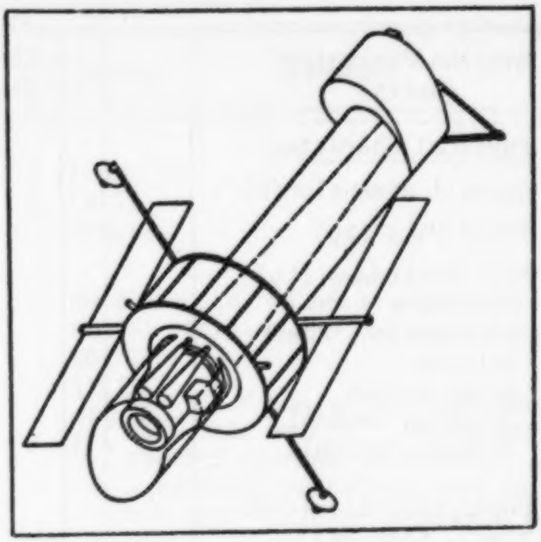
Lifetime: 10-15 years

Launch and Transfer Vehicles: Shuttle plus one OMS kit

Operational Location: 500 km orbit at 28.5 deg.

Total Mass at Operational Location: 10,000 kg.

Average Operational Power: 900 w.



OBJECTIVE: The Advanced X-ray Astrophysics Facility (AXAF) will serve as an X-ray astrophysics facility to complement visual and radio observations made from the ground and from space observatories such as the Space Telescope. The basic objectives are to determine the positions of X-ray sources, their physical properties as composition and structure, and the processes involved in x-ray photon production.

DESCRIPTION: AXAF is a free-flying, Shuttle launched spacecraft designed to view celestial X-ray sources. The facility has a 1.2 meter diameter Wolter type I mirror assembly which has a 0.5 arc sec resolution goal. Instruments using this mirror assembly are mounted in a rotating carousel at the focal plane. AXAF is being designed for on-orbit repair and instrument changeouts. Recovery for ground refurbishment and avionics redundance are planned to achieve a 10 to 15 year lifetime. NASA's Astrophysics Program is considering AXAF as a candidate new project for FY 83 with launch in 1987.

CRITICAL TECHNOLOGY NEEDS: The mirror assembly is composed of six mirror pairs whose materials, manufacturing, alignment and performance are critical in attaining the AXAF 0.5 arc second resolution goal. The science aspect cameras must be more accurate than conventional star trackers.

INSTRUMENT OR EXPERIMENT COMPLEMENT: A strawman instrument complement was defined by the Science Working Group, and consisted of both focal and non-focal plane instruments. Actual instruments would be selected through the Announcement of Opportunity (AO) process.

REFERENCES: "Advanced X-ray Astrophysics Facility", NASA/MSFC, May 1978.
"High Resolution Mirror Assembly Structured Systems", Smithsonian Astrophysical Observatory, SAO-AXAF-79-002.

CONTACTS: B.G. Davis, MSFC, (205)453-5727
M. Weisskopf, MSFC, (205)453-5133

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	11.5x3.1 (dia)	2, SOA	
Total Mass (kg)	10,000	2	
Mass breakdown (kg)			
Structure	5168	2, EV	Materials for optical assembly must minimize structure/thermal distortions.
Electronics, Power	1600	2	
Science	709	2	
X-ray optics	1377	2	
Pointing control	685	2	
Thermal control	431		
Deployed/articulated items, size (m)			
Solar Arrays(2)	6x2	2, SOA	Articulated, retractable for recovery.
TDRSS Antennas (2)	1.0(dia)	2, SOA	
Instrument Carousel	1.2x2.4 (dia)	2, SOA	Positions instruments in field-of-view.
Life			
Flight duration (years)	10-15	2, EV	Anticipate 1 ground return for refurbishment. Design for on-orbit replacement of science instruments and of spacecraft components by EVA. Enough redundancy has been designed into the subsystems to prevent single point failures that could endanger mission success.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	450	2	Need circular orbit high enough to assure orbit life until a revisit for reboost is possible.
Inclination (deg)	28.5		Must avoid pointing telescope line-of-sight to within 30° of the sun.

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^9-10^{11}	3, SOA	
Storage			
Capacity (bits)	10^{10}	3, SOA	
I/O rates (kbps)	1,000	3, SOA	Separate redundant recorders for science and housekeeping data.
Spacecraft processors/computers			
I/O rates (kbps)	ND	2, SOA	NSSC-1 or equivalent with about 32K words memory. Should have command storage to permit autonomous operations for up to one day. Science data rate high enough to prevent using spacecraft data bus.
Memory size (bits)	3×10^4	2, SOA	
Ground Processors/computers			
Memory size (bits)	ND	2, SOA	
Communications			
Minimum/maximum downlink rates (kbps)	40-1000	3, EV	Both omni and high gain antennas required. Use TDRSS S-band links for digital data. Science data rate will determine the type TDRSS service required. If over 50 KBPS continuous data then single access is required for AXAF.
Guidance & Attitude Control			
View direction	Celestial Sphere	2, SOA	Three-axis stabilized, inertial referenced spacecraft with star trackers, inertial reference units, Sun sensor and magnetometer. Reactor wheels used for all control modes; magnetic torquers for momentum management. Need development of solid state detectors for use in star trackers; 0.5 arc sec angular resolution goal for science output determination.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	0.15	2, SOA	
Stability (mrad)	0.15		
Aspect Determination(mrad)	2×10^{-3}	2, EV	

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	1200	2, SOA	Existing design solar arrays, articulated about one axis. Must have deployment and retention mechanisms for recovery.
Peak power consumed (We)			
Power breakdown (We)			
Subsystems	600		
Science	600		
Energy Storage			
Storage capacity (J)	10^7	2, SOA	
Discharge rate (We)	1200	2, SOA	Capacity NiCd batteries is 100 Ah; maximum discharge is 20%. Used for two-year mission before revisit with on-orbit exchange of components by EVA.
Discharge/recharge times (min)	30/60		
Thermal Control			
Component temperature (K)			
Optical Systems	295	2, SOA	Optical assembly protected by outer shell. Use heaters to minimize temperature differentials (<1K) along and across the optical assembly. Use outside insulation composed of mylar and paints to produce correct ambient temperatures. Optical bench and mirror materials selected to minimize structural/thermal deflections. Shunt regulators and radiators to regulate subsystems and science instrument temperature.
Subsystems/Inst.	295	2, SOA	
Component load (Wt)			
Optical Systems	100	2	
Subsystems/Inst.	ND	2	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion	NA		For the AXAF baseline, no on-board propulsion system identified for reboost or for an RCS function. An alternate propulsion system such as MMS/PM-I could be employed as in a reserve/supplementary capability.
Total ΔV required (m/sec)			
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: ADVANCED X-RAY ASTROPHYSICS FACILITY A-9

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Primary Mirror	NA	NA	A Wolter type I mirror assemlby composed of 6 mirror pairs; 1.2m diameter and 0.5 arc sec resolution goal at 1 keV (2,EV).
High Resolution X-ray Imaging	Spatial distribution of x-ray emissions	Angular resolution accuracy limited by primary mirror (2,SOA). Energy range of 0.1 to 8.0 keV with 10% resolution at 2 keV (2,EV)	Positions, structure, energy spectra and temporal variability of x-ray sources.
Low Resolution Imaging	Spatial distribution of x-ray emissions	Angular resolution of 10 arc sec over 1 deg. field-of-view (2,SOA); Energy range of 0.1 to 0.8 keV with 25% resolution at 2 keV (2,SOA)	Purpose same as high resolution imaging; Sensors (2) are imaging proportional counters (2,SOA).
High Resolution Dispersive Spectrometer	Energy x-ray emissions	Selected energy bands with 0.1% resolution at 4 keV (2,EV)	Determine species causing line emission in x-ray sources. Crystals provide energy dispersion (2,SOA).
Medium Resolution Spectrometer	Energy of x-rays	Selected energy bands with 1% resolution (2,SOA)	Determine species causing line emission in x-ray sources. Objective grating is dispersive element (2,EV).
Low Resolution Spectrometer	Energy of x-rays	Energy range of 0.4 to 8 keV with resolution of about 0.25 keV (2,SOA)	Measure continuum and broad band spectrum of x-ray sources. Cooled solid state detector (2,EV).
X-ray Polarimeter	Polarization of x-rays	Selected energy bands (e.g., 2.6 and 5.2 keV)	Measure linear polarization of x-rays. Polarization selected by crystal reflections (2,SOA).

ASTROPHYSICS

MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Status: Planned

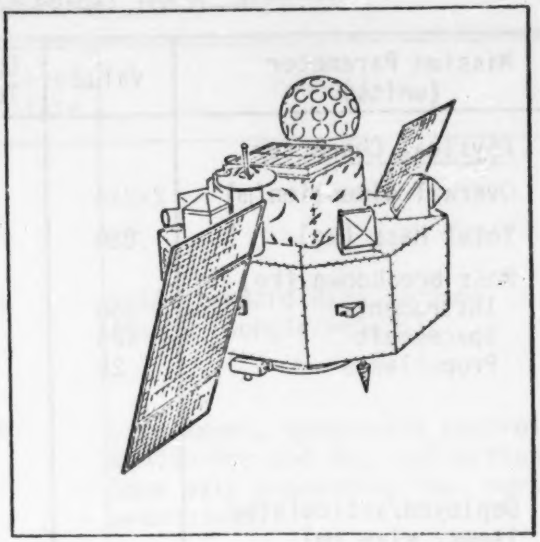
Lifetime: 2 years

Launch and Transfer Vehicles: Shuttle

Operational Location: 400 km orbit at 28.5 deg.

Total Mass at Operational Location: 1000 kg

Average Operational Power: 600 w



OBJECTIVE: The proposed XTE will be devoted to the study of temporal variability in X-ray emitting objects. This particular channel of astronomical study has been uniquely successful in determining the most fundamental properties of X-ray sources in the recent past. A large area counter system will be applied to the detailed interrogation of individual objects over long exposure times, while an all-sky monitor capability will interrogate all the remaining strong x-ray emitters simultaneously over longer timescales with decreased sensitivity. In this way, all timescales from microseconds to years will be sampled from the entire catalog.

DESCRIPTION: The proposed X-Ray Timing Explorer (XTE) program is an Explorer class payload to be Shuttle-launched during the mid to late-1980's. The spacecraft will be inserted into a 300 km circular orbit at 28.5° inclination by the Shuttle and raised to and maintained at 400 km by its on-board propulsion system. The attitude control system points the principal x-ray detector at selected celestial objects. A TDRSS multiple access channel will be used to communicate with XTE. In the event of a failure, or at the end of its nominal mission, the XTE spacecraft can be retrieved by the Shuttle. The next steps in XTE program are detailed studies and instrument selection. It is possible that XTE may become a cooperative program with the Dutch government which would supply the spacecraft and one experiment, the wide field camera.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT: A large area proportional counter and all-sky monitor or wide field camera will be used.

REFERENCES: X-Ray Timing Explorer, Goddard Space Flight Center, February 1980.

CONTACTS: W. Hibbard, GSFC, (301) 344-7889

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	2x2x4	3	
Total Mass (kg)	850	3	
Mass breakdown (kg)			
Instruments	350	3	
Spacecraft	425		
Propellants	25		
Deployed/articulated items, size (m)			
Solar arrays (2)	1x1.5	3	Rotate about single axis.
Life			
Flight duration	2-5	3	Shuttle checkout before deployment and retrieved in case of an on-board failure or at end of mission.
Number of spacecraft	1	3	
Orbit			
Periapse/apoapse altitudes (km)	400	3	Shuttle deploys and retrieves in a 300 km orbit. On-board propulsion system used for transfers between Shuttle orbit and 400 km operational orbit.
Inclination (deg)	28.5	3	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^9	3,SOA	
Storage			
Capacity (bits)	10^7	3,SOA	NASA standard data storage system (bubble memory).
I/O rates (kbps)	64		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3,SOA	Experiment, spacecraft control monitoring and data collection. Some data processing (eg. burst searchings).
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	3,SOA	Analysis of long time series, about 10^{10} bits, for temporal variations.
Communications			
Minimum/maximum downlink rates (kbps)	10/64	3,SOA	Downlink data is digital, use TDRSS S-band multiple access service.
Guidance & Attitude Control			
View direction	full sky	3,SOA	Three-axis stabilized for pointing at selected x-ray sources. Star, sun sensors; actuators are electromagnets interacting with the Earth's magnetic field.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	1.8	3	
Stability (mrad)	0.2	3	
Time accuracy (ms)	1.0	3	

MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	300	3	Solar array output is 1200 w in full sunlight.
Peak power consumed (We)	1500	3	
Power breakdown (We)			
Instruments	100	3	
Spacecraft	200		
Energy Storage			
Storage capacity (J)	10^7	3,SOA	Two 50 Ah NiCd batteries.
Discharge rate (We)	300	3	
Discharge/recharge times (min)	30/60	3	
Thermal Control			
Component temperature (K) All	280-300	3	Blankets, coatings, heaters for propellant.
Component load (Wt) All	ND	3	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

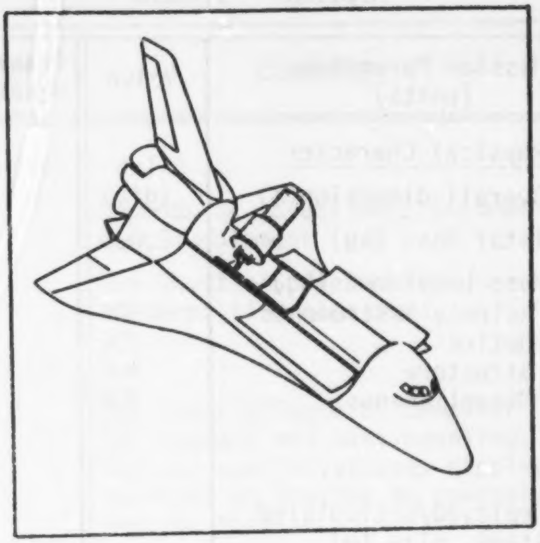
MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	60	3	Monopropellant hydrazine used to transfer between Shuttle accessable orbit at 300 km and XTE operational orbit at 400 km; also needed for drag makeup.
Thrust level(N)	250	3,SOA	
Isp(sec)	210	3,SOA	
Propellant mass(kg)	25	3	
Inert mass(kg)	ND	3	

ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS
MISSION: X-RAY TIMING EXPLORER (XTE) A-10

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Large Area Proportional Counter	Arrival times of x-rays with 10 μsec accuracy; also individual photon energy.	Energy range of 1 to 60 keV with 15% resolution at 6 keV (3,SOA)	The LAPC is specifically devoted to studies of individual sources (e.g., studies of pulsars, bursters and "milli-second bursts") on timescales of 0.1 ms to 1 day. An area of approximately one square meter is required (3,SOA). The pointing required is approximately 0.1 degree, and the telemetry rate required is 10 to 64 kbps. Instrument weight is about 350 kg (3,SOA).
All-sky Monitor	Source intensity as a function of time with sensitivity of 0.1% of Crab nebula.	Energy range of 3 to 6 keV (3,SOA)	Monitors the sky for x-ray sources with intensity variations on timescales of 1 day to 1 year (e.g., novae flares). Detector is position sensitive proportional counter (3,SOA). Data, pointing, mass requirements are small compared to LAPC.

MISSION: STARLAB A-11



Status: Planned

Lifetime: 10 years useful lifetime

Launch and Transfer Vehicles: Shuttle/Spacelab

Operational Location: 300 km orbit at 29 deg.

Total Mass at Operational Location: 2000 kg

Average Operational Power: ND

OBJECTIVE: Starlab is a Spacelab facility for astronomical observations in the visual and ultraviolet portion of the spectrum. Scientific investigations that can be conducted include high resolution, wide field imaging, far ultraviolet spectroscopy, precise spectrophotometry and polarimetry, and synoptic planetary observations. A Starlab mission can have unique scientific objectives and an appropriate instrument complement.

DESCRIPTION: Starlab is a 1-meter aperture f/15 telescope which will accommodate a wide variety of principal investigator-furnished focal plane instruments. New instruments are readily accommodated. The use of photographic film and rapid re-configuration are possible because Starlab is a flown in the Shuttle-attached mode. Mission durations are 7 to 30 days in an orbit at 300 km altitude. The mission uses the following Spacelab hardware: two pallets, the Instrument Pointing System and an igloo. Starlab is being considered by NASA's Astrophysics Program office for a new project start in FY 84 with launch possible in 1987.

CRITICAL TECHNOLOGY NEEDS: For the first Starlab mission, available technology is used. New instrument technologies can be accommodated on subsequent missions.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Strawman payload includes direct imaging camera, planetary imaging camera, precisely calibrated spectrophometer, far UV spectrograph, faint-object spectrograph and a high resolution spectrometer.

REFERENCES: "Starlab UV-Optical Telescope Facility, Volume 1 Summary Report", ORI, Inc, NASA-CR-159928, January 1979.

CONTACTS: T.P. Stecher, GSFC, (301)344-8718

MISSION TECHNOLOGY REQUIREMENTS

MISSION: STARLAB A-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			The entire Starlab is pointed at the desired celestial object by the Spacelab Instrument Pointing System.
Overall dimension(m)	5x1.5 (dia)	3, SOA	
Total Mass (kg)	2,000	3, SOA	Includes 19% margin; total Shuttle payload would include at least two Spacelab pallets and the igloo.
Mass breakdown (kg)			
Science Instruments	500		
Optics	350		
Structure	400		
Miscellaneous	300		
Deployed/articulated items, size (m)			
Secondary mirror	0.2	3, EV	For focus control, image motion compensation.
Instrument selecter	ND	3, SOA	
Life			
Flight duration (days)	7-30	3, SOA	Up to two Starlab flights per year over a 10-15 year useful life. Starlab refurbished on ground after each flight.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	300	3	Orbit with maximum solar occultations is preferred.
Inclination (deg)	28.5		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: STARLAB A-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	$10^9 - 10^{11}$	3, SOA	Depends on objectives, instrument complement
Storage			
Capacity (bits)	ND	3, SOA	Use Shuttle/Spacelab tape recorders; film also used.
I/O rates (kbps)	ND		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, SOA	Use Shuttle/Spacelab computer for command and data handling. Payload specialist uses displays/ terminal on Shuttle to control/ monitor Starlab.
Memory size (bits)			
Ground Processors/ computers			
Memory size (bits)	ND	3	
Communications			
Minimum/maximum downlink rates (kbps)	10-6,000	3, SOA	Use Shuttle to TDRSS links at either S- or K_u-band for digital data; video data provided for payload specialist could also be transmitted.
Guidance & Attitude Control			
View direction	All Sky	3, SOA	Shuttle and Spacelab IPS provide basic attitude control and pointing at desired celestial object. Shuttle flown in a quasi-inertial mode without firing attitude control thrusters. Starlab has image motion compensation consisting of fine guidance sensor, gyro and actuators for the secondary mirror.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	5×10^{-3}	3, SOA	
Stability (mrad)	1.5×10^{-4}	3, SOA	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: STARLAB A-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	1,000	3, EV	Power provided from Shuttle's fuel cells; requirement exceeds IPS specification.
Peak power consumed (We)	ND		
Power breakdown (We)			
Science Instruments	350		
Thermal Control	240		
Motion Compensation	175		
Commands, data	55		
Power	140		
Energy Storage	NA		
Storage capacity (J)			
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
Optical Assembly	295	3, SOA	Heaters, insulation and coatings are used to control temperatures to ±1K for optics and ±10K for remainder. Low thermal gradients in telescope are necessary to maintain image quality (focus).
Sensors/electronics	295	3, SOA	
Component load (Wt)			
Optical Assembly	200	3	
Sensors/electronics	ND	3	

ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: STARLAB A-11

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Direct Imaging Camera	Spatial Distribution of brightness for astronomical objects	Spectral range of 130 to 900 μm; subdivided by filters; Field-of-view of 0.5° with 0.4 arc sec resolution (3,SOA)	Map galaxies, nebulae, star clusters, etc. Uses film to record direct and intensified images. (3,SOA).
Planetary Camera	Spatial distribution of reflected light from solar system objects.	Spectral range of 120 to 900 μm with filters, polarizers; Field-of-view of 48 arc sec, diffraction limited resolution (0.3 arc sec); time resolution of 0.1 sec. (3,SOA).	Detector is a cooled 800 x 500 CCD array (3,SOA).
Far UV Spectrograph	Strength of emission/absorption lines in spectra of astronomical objects	Spectral range of 90 to 122 μm with resolution of one part $4x10^{-4}$. Field-of-view of 30 arc sec. (3,SOA)	Five microchannel arrays with 2048x128 format (3,SOA).
Precisely Calibrated Spectrophotometer	Strength of emission/absorption lines in spectra of astronomical objects	Spectral range of 90 to 1000 μm (3,SOA)	CCD and microchannel arrays (3,SOA).
Faint Object Spectrograph	Strength of emission/absorption lines in spectra of astronomical objects	Spectral range of 110 to 400 μm with 0.1% resolution (3,SOA)	2048x64 element microchannel array (3,SOA).
Echelle Spectrograph	Strength of emission/absorption lines in spectra of astronomical objects	Spectral resolution of one part in 10^5	SEC vidicon detector with 2000 pixels/line resolution (3,SOA).

ASTROPHYSICS

MISSION: X-RAY OBSERVATORY A-12

Status: Candidate

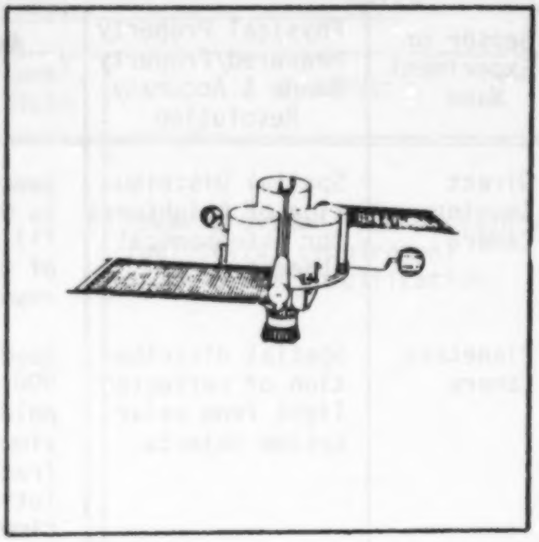
Lifetime: 2 years in orbit

Launch and Transfer Vehicles: Shuttle

Operational Location: 400 km orbit at 28.5 deg.

Total Mass at Operational Location: 3000- 3500 kg.

Average Operational Power: 850 w



OBJECTIVE: It is intended that the X-ray Observatory mission make scientific observations with broad bandwidth x-ray instruments which are needed to resolve problems in the areas of large-scale galactic phenomena, stellar structure and evolution, the nature the active galaxies, clusters of galaxies and cosmology.

DESCRIPTION: The x-ray observatory mission is designed to extend the previous observations in x-ray astronomy made by Uhuru, ANS, Ariel 5, SAS-3, and the HEAO series of satellites by providing more sensitive and time-correlated measurements over a broad spectral range (potentially as great as 40 eV to 300 keV). XRO could also support the AXAF mission. XRO will be launched from the Kennedy Space Center (KSC) on the Space Shuttle and placed in a 400-km, 28.5 deg. inclination orbit. The instruments, with the exception of the all-sky monitor, will be pointed with 1 arc min. accuracy to any area of interest in the sky. The XRO concept is based upon the support capabilities that can be provided by the Multimission Modular Spacecraft (MMS). The XRO mission is being considered by NASA's Astrophysics Program as a candidate for a new project start after FY 85.

CRITICAL TECHNOLOGY NEEDS: No new technology is required; however, improvements in on-board data processing and storage will be evaluated as they become available.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Potential instruments are all-sky monitor, wide-band imaging spectrophotometer, polarimeter, spectrometers (Bragg crystal and solid state nondispersive), XUV telescope, rotating modulation collimator and proportional and scintillation counter array.

REFERENCES:

CONTACTS: J. Gitelman, GSFC, (301)344-7889
E. Boldt, GSFC, (301)344-5913

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY OBSERVATORY A-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	ND	3, SOA	
Total Mass (kg)	3000-3500	3	
Mass breakdown (kg)			
Instruments	1300-1800		
Deployed/articulated items, size (m)			
Solar arrays(2)	ND	3	Articulated roll out arrays; articulated high gain antennas.
TDRSS antennas(2)	ND	3	
Life			
Flight duration (days)	730	3, SOA	
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	400	3, SOA	Nominal Shuttle orbit for XRO deployment. Lower altitude and/or inclination is preferred for lower background radiation belt fluxes.
Inclination (deg)	28.5		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY OBSERVATORY A-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	2.5×10^9	3, SOA	
Storage			
Capacity (bits)	10^8	3, SOA	NASA standard tape recorder or bubble memory.
I/O rates (kbps)	20-200		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3	On-board instrument sequencing, data processing.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	
Communications			
Minimum/maximum downlink rates (kbps)	ND	3, SOA	Prefer capability to use both single and multiple access S-band channels to TDRSS.
Guidance & Attitude Control			
View direction	All Sky	3, SOA	Three axis stabilized spacecraft points at any desired x-ray source. Implementation could be based on MMS attitude control subsystem. May need payload fine pointing sensor to meet accuracy/stability requirements for imaging and source locations.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	ND		
Stability (mrad)	ND		

MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY OBSERVATORY A-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	850	3, SOA	Use fold out solar cell arrays; articulated to point to Sun. Could use MMS power conditioning/control.
Peak power consumed (We)	ND	3	
Power breakdown (We) Instruments	200	3	
Energy Storage			
Storage capacity (J)	ND	3, SOA	
Discharge rate (We)	ND	3, SOA	Use NiCd batteries.
Discharge/recharge times (min)	30/60	3, SOA	
Thermal Control			
Component temperature (K)	ND	3	NOTE: If MMS support subsystems are used, they have adequate passive thermal control as part of their basic package. Earth instrument would have to provide its own thermal control.
Component load (Wt)	ND	3	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: X-RAY OBSERVATORY A-12

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3, SOA	May be needed for backup attitude control and/or altitude adjustments for drag make-up. Hydrazine system is a MMS mission unique option.
Thrust level(N)	ND		
Isp(sec)	ND		
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: X-RAY OBSERVATORY A-12

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
All-sky Monitor	Locations of variable sources with 1 deg. accuracy	Energy range of 1.5 to 20 keV (3,SOA)	Continuously monitor the entire sky for source variations, bursts, and transient objects. 6 detectors, each with a aperture of 0.04m^2 (3,SOA).
Rotating Modulation Collimator (RMC)	Location of sources with 5 arc sec accuracy	Energy range of 1.5 to 20 keV (3,SOA)	Proportional counters with 1m^2 aperture; rotating mechanical collimator (3,SOA).
Proportional and Scintillation Counter Array	X-ray flux from astronomical objects	Energy range of 1 to 300 keV with a broad band resolution. Temporal resolution of NDs.(3,SOA)	Measure temporal variations and broad band continuum spectrum. RMC for low energies and scintillator array for high energies. Both with 2m^2 apertures. (3,SOA).
Wide band Imaging Spectrophotometer	Map of x-ray flux from astronomical objects	Energy range of 0.15 to 200 keV in three wide bands. Angular resolution of 1 arc sec in low energy band (3,SOA)	Measure continuum spectra of sources in three bands. Focusing telescope and imaging proportional counter for 0.15 to 2keV; mechanically collimated proportional counters for 1.5 to 30keV; phoswitch scintillators for 20 to 200 keV (3,SOA).
Bragg Crystal Spectrometer	Spectrum of x-ray sources	Spectral resolution of 1 part in 5000 over range of 0.4 to 12 keV. (3,SOA)	Dispersive spectroscopy of discrete sources to identify line emission components. Detector aperture of about 1m^2 (3,SOA).
Solid State Non-dispersive Spectrometer	Spectrum of x-ray sources	Energy range of 0.4 to 8keV with resolution of about 2.5% (3,SOA)	Simultaneous spectroscopy of sharp spectral features (e.g., lines, edges, and continuum). Cryogenic detectors with area of about 0.3m^2 and hard x-ray concentrator. (3,SOA).

MISSION: COSMIC RAY OBSERVATORY A-13

Status: Candidate

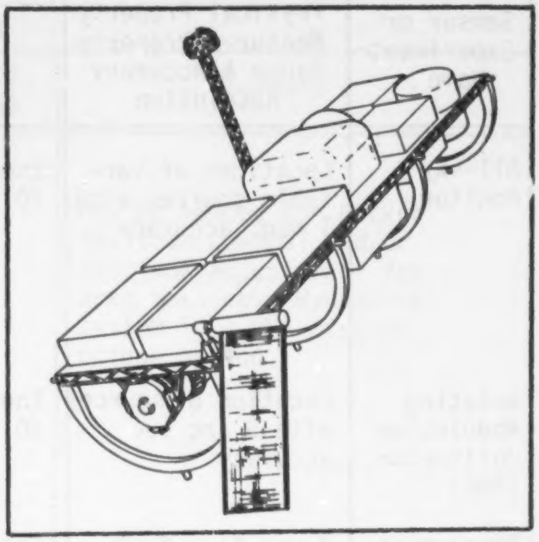
Lifetime: 2 years in orbit

Launch and Transfer Vehicles: Shuttle

Operational Location: 400 km Earth orbit at 56 deg.

Total Mass at Operational Location: 18,000 kg.

Average Operational Power: 1075 w.



OBJECTIVE: The overall objective of the Cosmic Ray Observatory is to study the compositio and energy spectrum of primary cosmic rays. Specific topics for study are: the charge composition of nuclei heaver than iron; the isotopic composition of nuclei of hydrogen through nickel; the relative abundance of constituents accelerated at sources (protons, electrons, ion nuclei, etc.) and produced in interactions in the interstellar medium (positrons, ^{10}Be, etc.); the energy spectra of electrons to 2 x 10^{12} eV, protons to 10^{15} eV, and nuclei to 10^{13}eV; the existence of exotic particles such as superheavy nuclei, monopoles and anti-nuclei.

DESCRIPTION: The CRO spacecraft will be inserted by the Space Shuttle into a 400 km circular orbit at 56 degrees inclination. This orbit assures a two year lifetime and will go to a high enough geomagnetic latitude to accommodate the isotopic composition studies. Pointing of the instruments to the local vertical (±25 degrees) will ensure 100% observation duty cycle. Communications will be accomplished via the Tracking and Data Relay Satellite System. Requirements for support subsystems are thought to be consistent with use of subsystems from the Multimission Modular Spacecraft program. This mission is a candidate new project start in the post 1985 timeframe.

CRITICAL TECHNOLOGY NEEDS: Not identified in preliminary studies.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Not determined in preliminary studies.

REFERENCES: "Cosmic Ray Observatory", NASA/GSFC, December 1977.

CONTACTS: J. Ormes, GSFC, (301)344-5798

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

A-13

MISSION: COSMIC RAY OBSERVATORY

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	15x5(dia)	3, SOA	Completely fills Shuttle cargo bay.
Total Mass (kg)	18,000	3	
Mass breakdown (kg)	ND	3	
Deployed/articulated items, size (m)			
Solar array	ND	3	
TDRSS antenna	ND	3	
Life			
Flight duration (days)	730	3, SOA	
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	400		
Inclination (deg)	56		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC RAY OBSERVATORY A-13

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	6×10^8	3, SOA	
Storage			
Capacity (bits)	ND	3, SOA	Tape recorder.
I/O rates (kbps)	ND	3, SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, SOA	
Memory size (bits)	ND	3, SOA	
Ground Processors/ computers			
Memory size (bits)	ND	3, SOA	
Communications			
Minimum/maximum downlink rates (kbps)	ND	3, SOA	Use TDRSS S-band multiple access service. (Maximum data rate is 50 kbps which should be adequate.)
Guidance & Attitude Control			
View direction	local vertical	3, SOA	Pointing requirements are minimal (within 25° of vertical) although knowledge of attitude with more accuracy is desired for studies involving arrival directions of cosmic rays.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	ND		
Stability (mrad)	ND		

MISSION TECHNOLOGY REQUIREMENTS

MISSION: COSMIC RAY OBSERVATORY A-13

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	1075	3, SOA	Solar array
Peak power consumed (We)	ND	3	
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	ND	3, SOA	NiCd batteries.
Discharge rate (We)	ND	3	
Discharge/recharge times (min)	30/60	3	
Thermal Control			
Component temperature (K)	ND		
Component load (Wt)	ND		

MISSION TFCHNOLOGY REQUIREMENTS

MISSION: COSMIC RAY OBSERVATORY A-13

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3, SOA	Propulsion system may be needed for backup attitude control and for altitude adjustments to compensate for atmospheric drag.
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

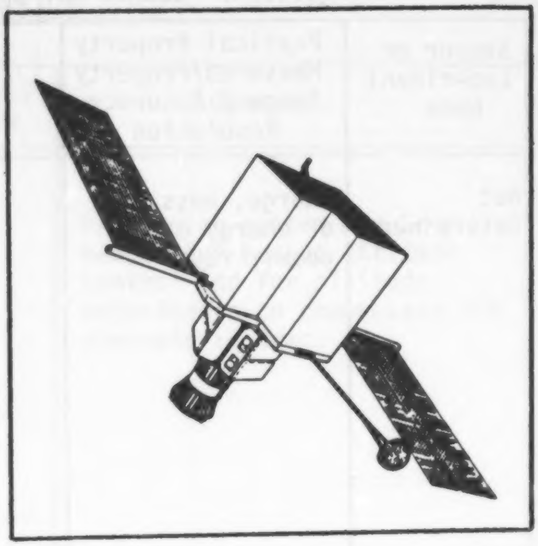
ASTROPHYSICS

SENSOR/EXPERIMENT PARAMETERS

MISSION: COSMIC RAY OBSERVATORY A-13

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Not Determined	Charge, mass and/or energy of cosmic rays		The CRO investigations will be performed using PI class instruments. Each instrument will be a particle telescope specifically designed to look at a given type of particle. A variety of techniques such as transition radiation detectors ionization chambers, cerenkov counters, superconducting magnets, ionization calorimeters and trajectory determination will be used in each experiment.

MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14



Status:	Candidate
Lifetime:	2 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	400 km orbit at 28.5 deg
Total Mass at Operational Location:	5200 kg
Average Operational Power:	1050 w

OBJECTIVE: The primary objective of the Large Area Modular Array of Reflectors (LAMAR) Mission is to conduct a full-sky survey for x-ray sources with at least as much sensitivity as the Einstein Observatory has provided for very limited areas. Additional objectives are observations of extended diffuse sources and of faint time variable objects.

DESCRIPTION: The LAMAR spacecraft will consist of an instrument module plus a spacecraft bus similar to the Multimission Modular Spacecraft. Because of its large size and mass, the instrument module will be the major structural element to which the other systems are attached. The instrument module contains multiple coaligned x-ray concentrators each of which produces an image on a detector. The data system combines the image information into a single image for transmission via TDRSS. It is intended that LAMAR be utilized as a national observatory. The large collecting area and moderate angular resolution of LAMAR compliment the properties of the Advanced X-ray Astrophysics Facility (AXAF). Thus, LAMAR is a mission which NASA is considering for launch in the early 1990's when AXAF would be operational. The Shuttle is used for launch, deployment, and checkout. Retrieval in the event of a spacecraft failure or at the end of the mission is possible.

CRITICAL TECHNOLOGY NEEDS: Alignment of concentrators and on-board processing of images are problems that should be solved during the development of similar instruments for Spacelab missions.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Large area modular array of reflectors.

REFERENCES: Astrophysics Project Concept Summary: Large Area Modular Array of Reflectors (LAMAR), NASA Headquarters (Astrophysics Division), February 1980.

CONTACTS: E. Mercanti, GSFC, (301) 344-7697

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	6 x 4 (dia)	3	
Total Mass (kg)	5200	3	
Mass breakdown (kg)			
Modular concentrators (8)	3200	3	
Instruments	550	3	
Spacecraft bus	1450	3	
Deployed/articulated items, size (m)			
Solar arrays (2)	3 x 6	3,SOA	Rotate about one axis.
Antenna Mast	4	3	Antenna diameter is 0.7 m and is electronically beam-steered.
Life			
Flight duration (yrs.)	2	3,SOA	Longer if Shuttle could resupply propellants, and refurbish spacecraft.
Number of spacecraft	1	3	
Orbit			
Periapse/apoapse altitudes (km)	400	3,SOA	Desire orbit with little atmospheric drag, but low altitude/inclination to avoid South Atlantic Anomaly.
Inclination (deg)	28	3	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	7×10^8	3,SOA	
Storage			
Capacity (bits)	ND	3,SOA	NASA Standard tape recorder or equivalent.
I/O rates (kbps)	ND		
Spacecraft processors/ computers			
I/O rates (kbps)	10^5	3,SOA	Used for image processing and to compute spacecraft position, velocity and time.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	Distribute data to scientific investigators.
Communications			
Minimum/maximum downlink rates (kbps)	8	3	Use S-band multiple access service of TDRSS. Note rate is 64 kbps without on-board image processing.
Antenna gain (dB)	14	3	0.76 m hemispherical antenna with 128 elements for electronic beam steering.
Guidance & Attitude Control			
View direction	all sky	3	Three-axis stabilization used to point instruments to a selected celestial position with 1 arc min accuracy. Orientation determined by star trackers, sun sensors and gyros. Global positioning system receiver/processor assembly provides position, velocity. Momentum wheels and hydrazine thrusters used for attitude control.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	0.28	3,SOA	
Stability (mrad)	0.14	3,SOA	

MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	1050	3,SOA	Two roll out solar arrays provide about 2000 w of power when normal to the sun.
Peak power consumed (We)	ND	3	
Power breakdown (We)			
Instruments	500	3	
Spacecraft bus	550	3	
Energy Storage			
Storage capacity (J)	10^7	3,SOA	Two NASA Standard 50 Ampere-hour NiCd batteries
Discharge rate (We)	1050	3	
Discharge/recharge times (min)	30/60	3	
Thermal Control			
Component temperature (K)	ND	3,SOA	Passive means (blankets, louvers, coating, etc.) are thought to be sufficient.
Component load (Wt)	ND	3	

ASTROPHYSICS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	120	3,SOA	For round trip transfer between Shuttle deployment/ retrieval orbit at 300 km and operating orbit at 400 km. Hydrazine monopropellant system with 200 kg allowance for drag makeup and attitude control.
Thrust level(N)	ND	3	
Isp(sec)	225	3,SOA	
Propellant mass(kg)	465	3	
Inert mass(kg)	ND	3	

ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS
MISSION: LARGE AREA MODULAR ARRAY OF REFLECTORS A-14

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Large Area Modular Array of Reflectors (LAMAR)	X-rays emitted by celestial sources	Energy range of about 0.2 to 4.0 keV (3,SOA). Field of view of 1.0 deg with angular resolution of 1.0 arc min (3,SOA)	Used for sensitive full-sky survey and for studies of faint source that are diffuse or time varying. Each module has four coaligned x-ray concentrations. A module has dimensions of 1 x 1 x 3 m and weighs about 400 kg. With 8 modules the effective collecting area is about 3 m^2 at 1.5 keV. The concentrators could employ either Wolter Type I or Kirkpatrick-Baez optics (3,SOA). The images formed by each module are to be combined into one by an on-board processor (3,SOA).

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

Status: Candidate

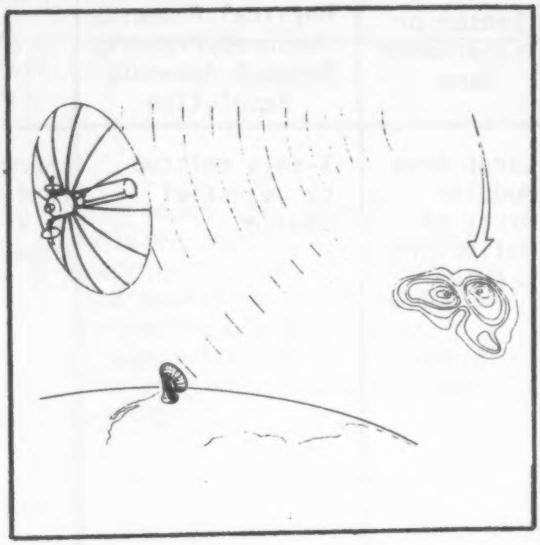
Lifetime: 3 years

Launch and Transfer Vehicles: Shuttle

Operational Location: Earth Orbit

Total Mass at Operational Location: Not determined

Average Operational Power: Not determined



OBJECTIVE: Radio interferometry over very long baselines provides maps of compact celestial radio sources with finer resolution, less ambiguity, and more efficiency than Earth-bound techniques.

DESCRIPTION: The Very Long Baseline Interferometer (VLBI) observatory is taken to low-Earth orbit by the Shuttle. A parabolic antenna with a diameter of 30 to 60 m is deployed. Celestial radio sources are observed simultaneously by the free-flying VLBI observatory and by one or more ground based observatories. Two orbiting VLBI observatories with larger orbit sizes could be used together to provide maps with even finer angular resolution.

CRITICAL TECHNOLOGY NEEDS: Deployable antennas (30 to 60 m), space-qualified hydrogen maser atomic frequency standard (or equivalent stability relayed from the ground), space-qualified cryogenic receivers (1-22 GHz).

INSTRUMENT OF EXPERIMENT COMPLEMENT: Low noise, cryogenic receivers (1-22 GHz) with 30 to 60 m antenna and hydrogen maser frequency standard.

REFERENCES: Preston, R.A., "VLBI with an Earth-orbiting Antenna", JPL Engineering Memo. 315-16, Feb. 1977.

CONTACTS:

R. Preston, JPL, (213)354-6895
B. Burke, MIT, (617)253-2572

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	30(dia)	3, SOA	
Total Mass (kg)	ND	3	
Mass breakdown (kg)	ND	3	
Deployed/articulated items, size (m)			
Deployable antenna	30-60 (dia)	3, EV	
Life			
Flight duration (years)	3	3	Longer lifetime (≈10 years) desirable; spacecraft not recoverable.
Number of spacecraft	1-2		
Orbit			
Periapse/apoapse altitudes (km)	1000	3	Higher periapse orbits can provide more angular resolution.
Inclination (deg)	>30		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^{11}-10^{14}	3, SOA	
Storage			
Capacity (bits)	ND	3	Scientific data transmitted directly to ground.
I/O rates (kbps)	ND		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3	
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	Cross-correlation of data from two sites.
Communications			
Minimum/maximum downlink rates (kbps)	10^7-10^9	3, SOA/EV	From low-Earth orbit use TDRSS K_u-band single access service for digital data. Higher orbit observatory would need direct link to Earth.
Guidance & Attitude Control			
View direction	All Sky	3, SOA	Implementation is not defined.
Position accuracy (km)	1		
Pointing accuracy (mrad)	0.01		
Stability (mrad)	0.01		

MISSION TECHNOLOGY REQUIREMENTS

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	ND	3	
Peak power consumed (We)	ND	3	
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	ND		
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)	ND	3	Special thermal environments needed for radio receivers and hydrogen maser frequency standard.
Component load (Wt)	ND	3	

MISSION TECHNOLOGY REQUIREMENTS

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

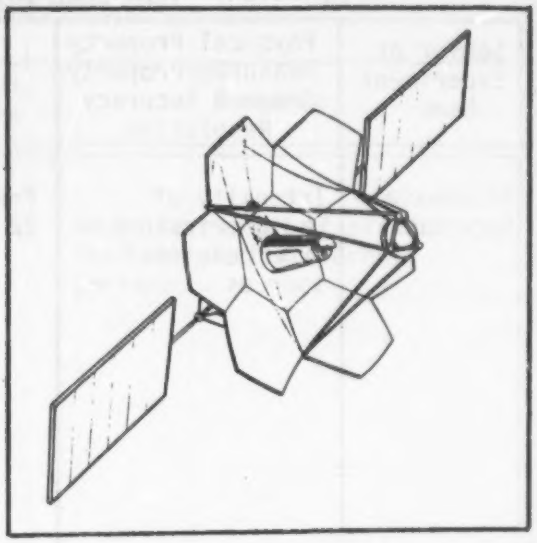
Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3	Would be needed if mission includes variable orbit periapse.
Thrust level(N)	ND		
Isp(sec)			
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

SENSOR/EXPERIMENT PARAMETERS

MISSION: VERY LONG BASELINE RADIO INTERFEROMETER A-15

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Microwave Receiver	Intensity of radio emissions from celestial sources	Frequency range of 1 to 22 GHz, (3,EV)	Used to make high angular resolution maps of celestial radio sources. Antenna diameter of 30 to 60 m (3,EV). Multi-channel receivers operating at 10 to 100K (3,EV). Hydrogen maser frequency standard (3,EV).

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16



Status:	Candidate
Lifetime:	About 10 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	Earth orbit at about 1000 km attitude.
Total Mass at Operational Location:	About 1000 kg.
Average Operational Power:	About 500 w.

OBJECTIVE: The Orbiting Submillimeter Telescope can carry out a wide range of astrophysical observations in a spectral region that is not accessible to ground-based observatories because of the absorption by the terrestrial atmosphere.

DESCRIPTION: The Orbiting Submillimeter Telescope (OST) is to be launched by the Shuttle into a low-Earth orbit. A 10 to 15 meter reflecting antenna would be deployed in orbit; it would collect the submillimeter waves from celestial sources for detection by one of several instruments. During its operational lifetime of about 10 years, the OST can be revisited to resupply cryogen and to replace instruments and subsystems. It could be operated as a major facility (like Space Telescope) with international participation.

CRITICAL TECHNOLOGY NEEDS: Large, precision surface, deployable reflector (10 to 15 m diameter); low noise radiometers at submillimeter wavelengths (mixers, local oscillators); broad-band digital spectrum analyzers.

INSTRUMENT OF EXPERIMENT COMPLEMENT: Coherent radiometers covering the 300-3000 GHz range, incoherent bolometers and Michelson type interferometer.

REFERENCES: "Submillimeter Wavelength Astronomy from Space", JPL Publication 740-3, April 1978.

CONTACTS:
P. Swanson, JPL, (213)354-3273
S. Gulkis, JPL, (213)354-5708
T. Kuiper, JPL, (213)354-5623

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	10-15 (dia)	3, SOA	
Total Mass (kg)	1000	3	
Mass breakdown (kg)	ND		
Deployed/articulated items, size (m)			
Antenna	10-15	3, EV	Deployed in orbit; possible active surface control.
Life			
Flight duration (years)	10	3, SOA	Revisits at one to two year intervals.
Number of spacecraft			
Orbit			
Periapse/apoapse altitudes (km)	1000	3, SOA	Solar illumination may be critical and may dictate a sun-synchronous orbit inclination.
Inclination (deg)	ND		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^5-10^6	3, SOA	
Storage			
Capacity (bits)	ND	3, SOA	Digital tape recorder.
I/O rates (kbps)	ND	3, SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, SOA	Microprocessor needed for control of instrument and data readout.
Memory size (bits)	ND	3, SOA	
Ground Processors/ computers			
Memory size (bits)	ND	3, SOA	
Communications			
Minimum/maximum downlink rates (kbps)	1-10	3, SOA	Digital data sent via TDRSS S-band multiple access link. Real-time interaction with spacecraft desireable.
Guidance & Attitude Control			
View direction	All Sky	3, SOA	System implementation is not determined. Antenna pointing requirements given.
Position accuracy (km)	ND		
Pointing accuracy (mrad)	0.01		
Stability (mrad)	0.01		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	500	3, SOA	Type of power source is not determined.
Peak power consumed (We)	1000		
Power breakdown (We)	ND		
Energy Storage			
Storage capacity (J)	ND	3	Requirements dependent upon choice for power source and orbit parameters.
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)			
Detectors	2-20	3, SOA	Liquid cryogen, refrigerators.
Antenna	ND	3	Temperature gradients and changes will distort surface.
Component load (Wt)			
Detectors	0.1	3	
Antenna	NA		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	NA		No orbital maneuvering is anticipated once in orbit.
Thrust level(N)	NA		
Isp(sec)	NA		
Propellant mass(kg)	NA		
Inert mass(kg)	NA		

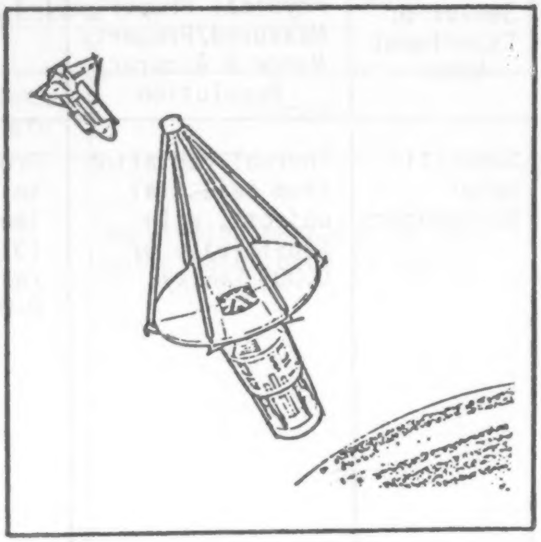
ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS

MISSION: ORBITING SUBMILLIMETER TELESCOPE A-16

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Submillimeter Radiometers	Thermal radiation from celestial objects, with sensitivity of 0.001 jansky.	Frequency range of 300 to 3000 GHz or wavelengths of 0.1 to 1 mm (3,EV); temperature resolution of about 0.01K (3,EV).	

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE

Status:	Candidate
Lifetime:	5 or more years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	Earth orbit at about 500 km altitude.
Total Mass at Operational Location:	16,000 kg.
Average Operational Power:	Not determined



OBJECTIVE: Investigations are conducted outside the Earth's atmosphere using an infrared astronomical telescope with a large aperture (10 to 30 meters diameter) which provides improved spatial resolution and energy collecting capability for the study of a wide variety of astrophysical phenomena throughout the infrared spectral region.

DESCRIPTION: The baseline design has a 12-meter diameter aperture which can be placed in orbit by one Shuttle mission. The collector consists of segmented sections deployed in orbit. A variety of instruments would be included to permit a wide range of scientific studies. Instrument cryogens are resupplied and instrument changeout are accomplished through periodic visits by the Shuttle to the free-flying satellite.

CRITICAL TECHNOLOGY NEEDS: Large, lightweight segmented optics; active figure control; sensors (IR CCD detectors); long life, low temperature cooling.

INSTRUMENT OF EXPERIMENT COMPLEMENT: An IR camera using detector arrays for photometry and mapping; grating spectrometers for low to moderate resolution spectroscopy; hetrodyne receivers for higher resolution spectroscopy; polarimeter.

REFERENCES:

CONTACTS: J. P. Murphy, ARC, (415)965-6520

MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE A-17

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	15x12	3, SOA	
Total Mass (kg)	16,000	3	
Mass breakdown (kg)	ND		
Deployed/articulated items, size (m)			
IR collector	12(dia)	3, EV	Segmented, deployed in orbit, active figure control. Some secondary support structure also deployed.
Life			
Flight duration (years)	5	3, SOA	Shuttle revisits at about one year intervals for cryogen resupply and instrument changeouts.
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	400-700	3, SOA	Telescope pointing controlled to avoid Earth, Moon, Sun.
Inclination (deg)	28-50		

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ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3	
Storage			
Capacity (bits)	ND	3	Tape recorders.
I/O rates (kbps)	ND	3	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3	Onboard computers needed for active figure control, pointing and stabilization.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	Ground computers required for operations/target sequencing.
Communications			
Minimum/maximum downlink rates (kbps)	ND	3, SOA	Digital data sent to ground station via TDRSS.
Guidance & Attitude Control			
View direction	All Sky	3, SOA	Method of implementation is not determined. It is assumed that segmented mirror will have sensors and actuators for figure control as well as accurate pointing and stabilization.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	$5x10^{-4}$	3	
Stability (mrad)	$5x10^{-5}$	3	

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

A-17

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	<3,000	3, SOA	Solar arrays assumed.
Peak power consumed (We)	ND		
Power breakdown (We)	ND		
Energy Storage			
Storage capacity (J)	ND		Batteries.
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)			
Detectors	2	3	Cryogenic cooling required for instrument detectors; radiative cooling may be required to achieve low temperatures for optics; normal thermal control techniques will be used for support subsystems.
Optics	170	3	
Component load (Wt)			
Detectors	ND		
Optics	ND		

ASTROPHYSICS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE A-17

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND		Required only if orbit changes are needed after Shuttle deployment.
Thrust level(N)	ND		
Isp(sec)			
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

ASTROPHYSICS
SENSOR/EXPERIMENT PARAMETERS

MISSION: LARGE AMBIENT DEPLOYABLE IR TELESCOPE A-17

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Infrared Camera	Map of infrared emission from celestial sources	ND	Use cryogenically cooled CCD arrays and specialized filters (3,EV).
Spectrometer	Spectrum of infrared emission from celestial sources	ND	Use grating for dispersion; cooled CCD array is possible detector (3,EV).
Hetrodyne Interferometer	Spectrum of infrared emission from celestial sources	ND	Use advanced IR detectors (sensitivity and wavelengths) and mixers (3,REV); all cooled.

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SOLAR TERRESTRIAL

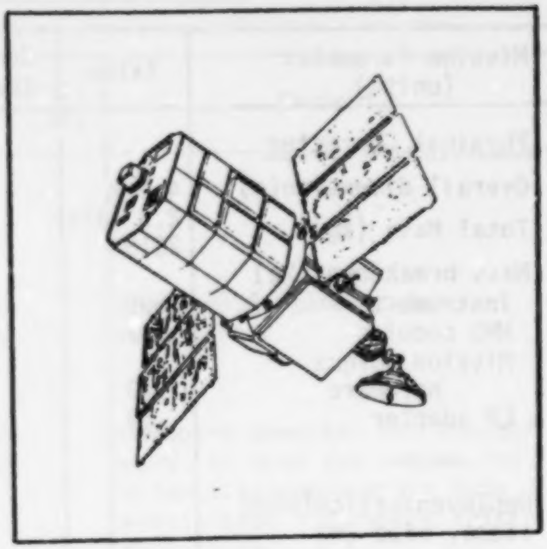
The Solar Terrestrial program objective is to understand the important physical processes in the sun, in the solar neighborhood, in the earth-space region, and in the upper atmosphere. Current efforts include remote observations of the sun and the various manifestations of the solar cycle, and remote and in situ measurements in the near-earth region. Future emphasis will be on more detailed investigations of cause and effect, using measurements close to the sun and from simultaneous measurements in widely separated locations in the solar system.

Solar Terrestrial Missions

No.	
S-1	**Solar Maximum Mission is dedicated to studies of solar activity occurring in active regions, sunspots, and especially in solar flares.**
S-2	**Dynamics Explorer is to investigate the strong interactive processes coupling the hot, tenuous convecting plasmas of the magnetosphere and the cooler, denser plasmas and gases corotating in the earth's ionosphere, upper atmosphere and plasmasphere.**
S-3	International Solar Polar Mission begins exploration of poles.
S-4	Solar Optical Telescope (SOT) is to obtain high resolution data which is required to solve fundamental problems in solar physics.
S-5	Chemical Release Module Facility will have the capability of multiple releases of chemical into the magnetosphere/ionosphere system.
S-6	Active Magnetospheric Particle Tracer Experiment is designed to study the question of access of solar wind ions into the magnetosphere.
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN) is to determine the energy flow through the coupled heliosphere-magnetosphere-ionosphere system.
S-8	Solar Soft X-Ray Telescope has as its purpose fundamental observations of the outer solar atmosphere.
S-9	Subsatellite Facility provides a platform for plasma diagnosis at locations near the Shuttle/Spacelab.
S-10	Plasma Turbulence Experiment is to investigate and describe the mechanisms of plasma turbulence in the sun-earth environment.
S-11	Solar Probe will make the first direct exploratory venture to the vicinity of the sun.
S-12	Solar Terrestrial Observatory is to perform long-term studies of the coupling between sun-magnetosphere-ionosphere atmosphere.
S-13	Solar Cycle and Dynamics Mission is to study long term solar phenomena and short time-varying solar mechanisms.

SOLAR TERRESTRIAL
MISSION: SOLAR MAXIMUM MISSION S-1

Status:	Approved
Lifetime:	1 year
Launch and Transfer Vehicles:	Delta 3910
Operational Location:	575 km orbit at 28.5 deg.
Total Mass at Operational Location:	2315 kg
Average Operational Power:	730 w



OBJECTIVE: The Solar Maximum Mission (SMM) is dedicated to studies of solar activity occurring in active regions, sunspots and especially in solar flares. Observations are to be conducted in the ultraviolet, x-ray and gamma-ray regions of the spectrum with Earth-based instruments providing coverage at radio and optical wavelengths.

DESCRIPTION: The spacecraft that is used for the Solar Maximum Mission is the NASA Multimission Modular Spacecraft (MMS). The components of the MMS are the power, attitude control and communications and data handling subsystems. Each subsystem is housed in a separate module which provides thermal control as well as mechanical and electrical interfaces to the MMS structure and electrical harness. The spacecraft is pointed toward the sun during the daylight portion of each orbit. The experiment module contains the instruments and a fine sun sensor. Some instruments have the ability to raster over the solar disk. The SMM spacecraft is designed for retrieval by the Shuttle and for on-orbit changeout of MMS modules.

CRITICAL TECHNOLOGY NEEDS: SMM is the first application for the Modular Multimission Spacecraft and the first satellite to use TDRSS. Instrument alignment is critical.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Soft x-ray polychromator, gamma ray spectrometer, hard x-ray imaging spectrometer, hard x-ray burst spectrometer, coronagraph/polarimeter, UV spectrometer and polarimeter and active cavity radiometer.

REFERENCES: Solar Maximum Mission, NASA News Release No. 80-16, February 6, 1980.

CONTACTS: P. Burr, GSFC, (301) 344-8536

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR MAXIMUM MISSION S-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4.0 x 2.3 (dia)	1	
Total Mass (kg)	2315	1	
Mass breakdown (kg)			
Instruments	595	1	
MMS modules	717	1	
Mission unique hardware	940	1	
LV adapter	69	1	
Deployed/articulated items, size (m)			
Solar arrays (2)	1.2 x 1.8	1,SOA	Fixed.
TDRSS antenna	1.3 (dia)	1,SOA	Steerable.
Life			
Flight duration (yrs.)	1	1	Has capability for a longer flight.
Number of spacecraft	1	1	Designed for Shuttle retrieval and on-orbit replacement of modules.
Orbit			
Periapse/apoapse altitudes (km)	575	1	Orbit decay to a 500 km altitude expected before Shuttle retrieval is attempted.
Inclination (deg)	28.5	1	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR MAXIMUM MISSION S-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	5×10^9	1,SOA	
Storage			
Capacity (bits)	3×10^8	1,SOA	Three NASA Standard tape recorders.
I/O rates (kbps)	16/1024	1,SOA	
Spacecraft processors/ computers			
I/O rates (kbps)	250	1,SOA	On-board computer has 18-bit/word; is used for sequencing, scientific/engineering data acquisition via remote interface units.
Memory size (bits)	48K	1,SOA	
Ground Processors/ computers			
Memory size (bits)	ND	1,SOA	Dedicated minicomputer at GSFC used to control spacecraft and to distribute data to experimenters.
Communications			
Minimum/maximum downlink rates (kbps)	16/1024	1,SOA	Digital data transmitted over S-band link. SMM is able to use GSTDN and TDRSS in the single and multiple access modes. Real time data sent at 16 kbps; stored data sent at 1024 kbps.
Guidance & Attitude Control			
View direction	Sun	1,SOA	SMM is a three-axis inertially stabilized platform. A fine sun sensor makes it possible for SMM to point at any point on the solar disk with the required accuracy and stability. The MMS subsystem contains coarse sun sensors, magnetometers star trackers and inertial reference units. Magnetic torquers and momentum wheels are the MMS control devices.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	0.025	1,SOA	
Stability (mrad)	0.010	1,SOA	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR MAXIMUM MISSION S-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	730	1,SOA	Two solar cell arrays provide about 1700 w of raw power.
Peak power consumed (We)	2880	1	Peak capability.
Power breakdown (We)			
Instruments	105/180	1	Minimum/Maximum
MMS modules	303/592	1	
Heaters	4/117	1	
Energy Storage			
Storage capacity (J)	6×10^6	1,SOA	Three 20 Ampere-hour Ni-Cd batteries.
Discharge rate (We)	730	1	
Discharge/recharge times (min)	30/60	1	
Thermal Control			
Component temperature (K)			
Instruments/Subsystems	295	1,SOA	Louvers, blankets, coatings, heaters used to maintain stable thermal environments for instruments and subsystems.
Component load (Wt)			
Instruments/Subsystems	ND	1	
Chemical Propulsion	NA		

SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: SOLAR MAXIMUM MISSION S-1

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Soft X-ray Polychromator	Solar X-ray emission	Spectral range of 0.14 to 2.24 nm; with resolution of 0,011 to 0.1% (1,SOA). Angular field-of-view of 7 arc min with resolution of 10 arc sec (1,SOA). Time resolution to 0.1 sec (1,SOA).	Used to investigate highly ionized plasmas (temperatures of 1.5 to 50 million K) associated with solar activity. Flat and bent crystal spectrometers; proportional counter detectors (1,SOA).
Gamma Ray Spectrometer	Solar gamma ray emission; flux range of 10^{-3} to 10 photons/cm^2/sec.	Spectral range of 0.3 to 17 MeV for primary detectors with 7% energy resolution (1,SOA). Auxillary detectors cover 10 to 160 keV and 10 to 160 MeV. Temporal resolution is about 1 sec. (1,SOA) Observe full sun.	Used to study gamma ray emissions from flares. Seven NaI scintillators are 7.6 by 7.6 cm (1,SOA) Active CsI shield. Auxillary detectors are NaI and CsI.
Hard X-ray Imaging Spectrometer	Solar x-ray emission	Field of view is 160 arc sec with 8 arc sec resolution (1,SOA). Spectral range of 3.5 to 30 keV is divided into six energy channels (1,SOA). Time resolution is 1.5 sec (1,SOA).	Measures position, structure and thermodynamic properties of hot thermal and nonthermal sources in active regions. Detectors are arrays of small proportional counters (1,SOA). Grid collimators provide angular resolution (1,SOA).
Hard X-ray Burst Spectrometer	Solar x-ray emission	Spectral range of 20 to 300 keV divided into 16 energy channels (1,SOA). Spectrum acquired in 0.1 sec; single channel mode has time resolution of 1 msec (1,SOA).	Used for studies of accelerated particles. CsI scintillators used for detector (71 cm^2) and for anticoincidence shield (1,SOA).

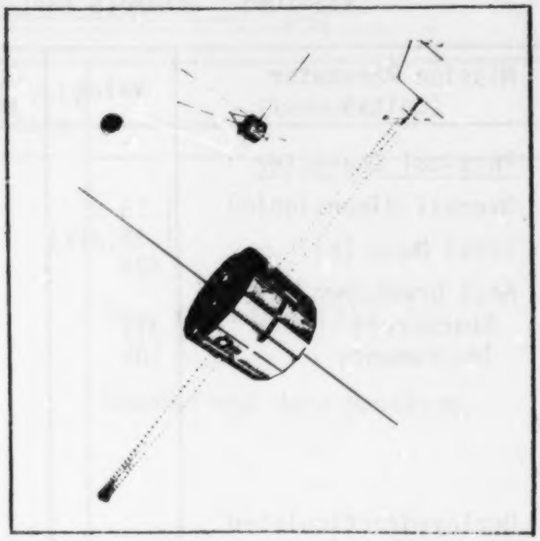
SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: SOLAR MAXIMUM MISSION S-1

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Coronagraph/ Polarimeter	Coronal emissions with sensitivity of 3×10^{-10} of the solar brightness	Field of view is 1.5 to 6 solar radii with spatial resolutions of 6.4 and 12.8 arc sec (1,SOA). Seven filters between 0.4 and 0.7 μm; three polarization filters at 60 deg intervals (1,SOA)	Measure response of corona to solar activity and make synoptic observations of corona. Externally occulted coronagraph uses meshless SEC vidicon detector (1,SOA) has dedicated tape recorder (1,SOA)
Ultraviolet pectrometer and olarimeter	Solar and coronal ultraviolet emissions and also extinction of sunlight through Earth's atmosphere	Spectral range of 110 to 300 nm with 0.001 nm resolution (1,SOA). Entrance aperature of 1 to 30 arc sec rastered over 4 arc min field (1,SOA)	Study physical conditions (temperature, density, velocity, magnetic fields) in active regions and flares. Measure composition of Earth's atmosphere. Gregorian telescope has rastered secondary (1,SOA). Variable dimensions and rotating quarter-wave plate at entrance aperture to monochrometer; several photomultipliers observe light dispersed by grating (1,SOA).
Active Cavity Radiometer	Solar irradiance with 0.1% resolution and 0.5% accuracy	Spectral range from far ultraviolet to far infrared; observe full sun (1,SOA).	Measure total solar irradiance; look for variations in solar output. Three electrically self-calibrated, conical cavity pyroheliometers (1,SOA).

MISSION: DYNAMICS EXPLORER S-2

Status:	Approved
Lifetime:	2 years
Launch and Transfer Vehicles:	Delta 3913
Operational Location:	Two spacecraft in polar, coplanar orbits
Total Mass at Operational Location:	424 kg (each)
Average Operational Power:	55 w (each)



OBJECTIVE: The primary scientific objective of the Dynamics Explorer program is to investigate the strong interactive processes coupling the hot, tenuous convecting plasmas of the magnetosphere and the cooler, denser plasmas and gases corotating in the Earth's ionosphere, upper atmosphere and plasmasphere.

DESCRIPTION: The Dynamics Explorer (DE) mission consists of two spacecraft (SC) to be launched simultaneously from the Western Test Range (WTR) and placed into polar, coplanar orbits. Individually, each SC is capable of contributing to scientific knowledge. However, the mission basically relies on correlative sets of measurements, from the two SC. DE-B will have a perigee lower than 350 km for neutral composition and temperature and wind measurements, and an apogee greater than 1000 km to allow measurements above the interaction regions for suprathermal ions and plasma flow measurements at the feet of the magnetospheric field lines. DE-A will have an apogee of 3.90 Earth radii for global auroral imaging, wave measurements in the heart of the magnetosphere, and crossing of auroral field lines at several Earth radii. This description applies to DE-A; however, significant differences between the two spacecraft are noted.

CRITICAL TECHNOLOGY NEEDS: None, development is complete.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Magnetometer, plasma wave instrument, spin-scan auroral imager, retarding ion mass spectrometer, high altitude plasma instrument and energetic ion composition spectrometer.

REFERENCES: Dynamics Explorer Support Instrumentation Requirements Document, GSFC, 31 August 1979.

CONTACTS: G. Hogan, GSFC, (301) 344-5977

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: DYNAMICS EXPLORER S-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	1.15 x 1.35(dia)	1	Each spacecraft.
Total Mass (kg)	424	1	
Mass breakdown (kg)			
Spacecraft	319	1	
Instruments	105		
Deployed/articulated items, size (m)			
Wire antennas (2)	100	1,SOA	DE-B antennas about 10 m.
Tubular antennas (2)	4	1	
Astromast booms (2)	5	1	
Antenna boom (1)	1.5	1	
Life			
Flight duration (years)	2	1,SOA	Minimum mission is one year; DE-A lifetime limited by sensitivity of electronic parts to radiation; DE-B lifetime limited by atmospheric drag.
Number of spacecraft	2	1	
Orbit			
Periapse/apoapse altitudes (km)	675/ 24,875	1,SOA	DE-B orbit is 385 x 1300 km; both spacecraft in coplanar, polar orbit.
Inclination (deg)	90	1	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: DYNAMICS EXPLORER S-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	4×10^8	1,SOA	
Storage			
Capacity (bits)	4×10^8	1,SOA	Tape recorders (2).
I/O rates (kbps)	16/128	1	
Spacecraft processors/ computers			Command and data handling.
I/O rates (kbps)	1	1,SOA	
Memory size (bits)	40,960	1	
Ground Processors/ computers			
Memory size (bits)	NA	1	
Communications			
Minimum/maximum downlink rates (kbps)	1/131	1,SOA	Digital data transmitted at S-band via STDN; also 75 kHz analog link for real-time plasma wave data. DE-B can use TDRSS, too.
Uplink rates (kbps)	0.25/1.0	1	
Guidance & Attitude Control			
View direction	NA	1,SOA	Spin-stabilized. Spin rate is 10 rpm; spin axis is normal to orbit plane. Sun and Earth limb sensors; electromagnetics acting against Earth's magnetic field are used to alter spin axis. DE-B is a nadir pointing three-axis stabilized spacecraft which also has momentum wheels.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	10	1,SOA	
Stability (mrad)	NA		

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: DYNAMICS EXPLORER S-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	55	1,SOA	Solar cells.
Peak power consumed (We)	85	1	
Power breakdown (We)			
Spacecraft	25	1	
Instruments	60		
Energy Storage			
Storage capacity (J)	1.2×10^6	1,SOA	NiCd batteries.
Discharge rate (We)	55	1	
Discharge/recharge times (min)	varies	1	
Thermal Control			
Component temperature (K)			
all electronics	293	1,SOA	Controlled by passive means.
Component load (Wt)	NA	1	
Chemical propulsion	NA		Delta launch vehicle used to provide initial spin orientatio and spin rate for both spacecraft.

SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: DYNAMICS EXPLORER

S-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Plasma Wave Instrument	Spatial, temporal, spectral and wave characteristics of ambient electromagnetic radiation	Frequency range of 2 Hz to 2 MHz for electric fields and 100 Hz to 400 kHz for magnetic fields (1,SOA)	Measures noise phenomena, especially auroral radiation, VLF hiss and electrostatic waves. Uses long dipole and magnetic loop antennas feeding five different radio receivers (1,SOA).
Magnetometer	Earth's magnetic field with range of 0 to 62,000 nT and resolution of 1.5 nT	Frequency range of 0 to 25 Hz (1,SOA)	Magnetic field data is used for studies of the magnetosphere, ionosphere and mutual coupling. Instrument is three-axis fluxgate magnetometer mounted on 5 m boom (1,SOA).
Spin-scan Auroral Imager	Spatial distribution and temporal characteristics of auroral emissions	Narrowband (~1 nm) spectral coverage at 630, 558, 391, 136, 130 and 122 nm (1,SOA)	Used to study auroral emissions produced by various excitation processes. Two spin-scan photometers using photomultiplier detectors (1,SOA).
Retarding Ion Mass Spectrometer	Energy and mass of plasma ions	Detailed composition in the 1 to 64 AMU range (1,SOA); density temperature and flow velocity of H^+, He^+ and O^+ (1,SOA)	Measures plasma properties in ionosphere, plasmasphere, plasma trough and polar cap. Retarding potential analyzer--followed by parallel plate/ceramic magnet mass analyzer; uses 3 electron multiplier detectors (1,SOA).
Energetic Ion Composition Spectrometer	Energy and mass of plasma ions	Energy range of 0 to 17 keV per unit charge and mass range of 1 to 138 AMU (1,SOA)	Determines composition of magnetospheric ions; used to find plasma acceleration sources. Curved plate electrostatic energy analyzer (in 32 steps) followed by a cylinderical plate/permanent magnet mass analyzer; uses electron multiplier detector (1,SOA).

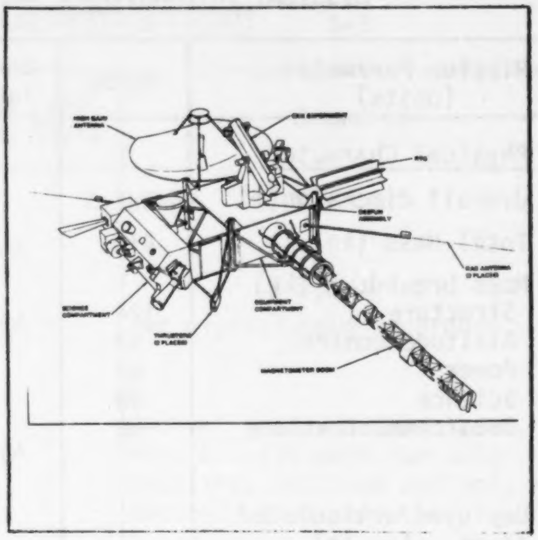
SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: DYNAMICS EXPLORER S-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
High Altitude Plasma Instrument	Phase-space distributions of electrons and positive ions	Energy range of 5 eV to 25 keV (1,SOA); variable energy and temporal resolution	Data used in studies of plasma sources and acceleration processes in Earth's magnetosphere. Five electrostatic analyzers at angles of 78, 84, 90, 96 and 102 deg form the spin axis; 32 step energy spectrum; separate electron, positive ion sensors (1,SOA).

SOLAR TERRESTRIAL
MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM) S-3

Status:	Approved
Lifetime:	4.5 years
Launch and Transfer Vehicles:	Shuttle/IUS(Twin/Spinner)
Operational Location:	Heliocentric orbit
Total Mass at Operational Location:	410 kg
Average Operational Power:	250 w



OBJECTIVE: The primary objectives of the ISPM mission are to investigate as a function of solar latitude, the properties of the solar corona, the solar wind, the structure of the Sun-wind interface, the heliospheric magnetic field, solar and non-solar cosmic rays and the interstellar/interplanetary neutral gas and dust during the declining phase of the solar cycle. The secondary mission objectives are to perform investigations of interplanetary physics during the initial Earth-Jupiter phase and the Jovian magnetosphere during the Jupiter flyby phase.

DESCRIPTION: The ISPM Project uses a NASA Spacecraft and an ESA Spacecraft. The two spacecraft are launched from Cape Canaveral by a single NASA Space Transportation System (STS) vehicle with a 3-stage Inertial Upper Stage (IUS) used for injection into an interplanetary orbit toward Jupiter. Shortly after injection, the two spacecraft are separated from the third stage of the IUS. The flight paths take both spacecraft nearly in the ecliptic plane to Jupiter with a small separation in Jupiter arrival time achieved by post-launch maneuvers. By choosing the proper Jupiter encounter strategy, the gravitational field of Jupiter is used to deflect both spacecraft into out-of-ecliptic trajectories, one to the north and the other, south. After Jupiter flyby, both spacecraft travel in heliocentric out-of-ecliptic orbits with high heliographic inclination and passages over the rotational poles of the Sun at 1.6 AU to 2.0 AU from the Sun.

CRITICAL TECHNOLOGY NEEDS: Radioisotope thermal generator, instrument development, radiation tolerant electronics.

INSTRUMENT OR EXPERIMENT COMPLEMENT: White light coronagraph/x-ray XUV telescope (CXX), solar x-ray/cosmic gamma ray burst, comprehensive particle analysis, solar wind, magnetic field, unified radio and plasma wave, interstellar gas measurement, zodiacal light/background starlight.

REFERENCES: ISPM Project Plan, JPL document no. PD 628-1
Science Requirement Document, JPL document no. PD 628-50
NASA Spacecraft Systems Specification, JPL document no. PD 628-201

CONTACTS: W. I. Purdy, JPL (213) 354-5122
J. P. Slonski, JPL (213) 354-2844

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM)   S-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4x2x1.5	1	NASA Spacecraft.
Total Mass (kg)	410	1	
Mass breakdown (kg)			
Structure	124	1	Includes 33 kg expendables.
Attitude control	93	1	
Power	65	1	
Science	60	1	
Data/communications	68	1	
Deployed/articulated items, size (m)			
CXX experiment	1.1	1,SOA	On despun platform; $0-60^{\circ}$ cone angles.
Magnetometer boom	13	1,SOA	
Dipole antenna	100	1,SOA	Tip to tip.
Life			
Flight duration (yrs.)	4.5	1,SOA	Design policy is to have no single point critical failure modes. One NASA and one ESA spacecraft.
Number of spacecraft	2	1	
Orbit			
Periapse/apoapse altitudes (AU)	1.0/5.2	1,SOA	Jupiter gravity assist (perijove at about 6R_J) used to attain high heliographic inclination. One spacecraft passes over solar north pole; other goes over south pole. During cruise to Jupiter the two are in the ecliptic and within 0.01 AU of each other.
Inclination (deg)	80	1	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM) S-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	1.4×10^9	1,SOA	
Storage			
Capacity (bits)	6×10^8	1,SOA	Two digital tape recorders.
I/O rates (kbps)	<45	1	
Spacecraft processors/ computers			
I/O rates (kbps)	<200	1,SOA	Central processor and three remote units used for data handling, attitude control, command sequencing.
Memory size (bits)	ND	1	
Ground Processors/ computers			
Memory size (bits)	ND	1	
Communications			
Minimum/maximum downlink rates (kbps)	0.01/48	1,SOA	Primary path is X-band (22 w) to DSN; S-band (5 w) backup.
Uplink rate (kbps)	0.125	1,SOA	
Communication distance (AU)	<6	1	
High gain antenna (m)	2	1,SOA	Fixed, aligned with spin axis.
Guidance & Attitude Control			
View direction	full sky	1	Spin stabilized; spin rate is 5 rpm; spin axis points to Earth. CXX experiment which is mounted on despun platform has most sensitive pointing requirements. Sensors are not determined; propulsion system used for control.
Position accuracy (km)	1000	1,EV	
Pointing accuracy (mrad)	0.05	1,EV	
Stability (mrad)	0.02	1,EV	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM) S-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	250	1,EV	Radioisotope thermal generator is rated at 290 w.
Peak power consumed (We)	250	1	
Power breakdown (We)			
Science	67	1	
Data/communications	126	1	
Attitude control	27	1	
Power	15	1	
Thermal control	8	1	
Energy Storage			
Storage capacity (J)	4	1,SOA	Capacitor bank used to prevent short transient loads from overloading the main power bus.
Discharge rate (We)	ND	1	
Discharge/recharge times (min)	ND/0.1	1	
Thermal Control			
Component temperature (K)			
Spacecraft bus	295	1,SOA	Heaters (RTU and electrical), blankets, louvers.
Science compartment	277	1,SOA	
CXX sensor	188	1,SOA	Passive cooler for CCD device.
Component load (Wt)			
Spacecraft bus	160	1	Thermal power dissipation.
Science compartment	34	1	
CXX sensor	ND	1	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM) S-3

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	135	1,SOA	Trajectory corrections and control of spin axis/rate. System is monopropellant hydrazine with 8 thrusters.
Thrust level(N)	<4	1,SOA	
Isp(sec)	<220	1	
Propellant mass(kg)	34	1	
Inert mass(kg)	12	1	

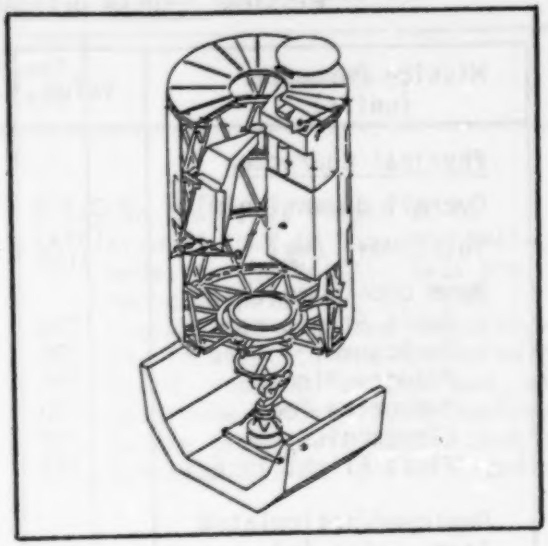
SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: INTERNATIONAL SOLAR POLAR MISSION (ISPM) S-3

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
White Light Coronagraph/ X-ray XUV Telescope	Brightness, polarization of solar chromosphere and corona	White light spectral range is 400 to 650 nm with 10 filters, X-ray XUV is 0.3 to 55 nm with 15 filters (1,SOA); spatial resolution is 8 and 4 arc sec, respectively (1,EV)	Obtain three-dimensional structure of corona, its influence on solar wind and its dependence on underlying phenomena. Cooled CCD sensors with 800 x 800 format (1,EV).
Solar X-ray/ Cosmic Gamma Ray Burst	Cosmic gamma rays and Jovian x-rays, solar electrons	Gamma ray energies of 25 to 300 keV (1,SOA)	Two CsI scintillator shells with phototubes and two Si surface barrier detectors (1,SOA).
Comprehensive Particle Analysis	Solar and cosmic electrons, protons and heavier nuclei	Particle energy range is 40 keV/nucleon to 400 MeV/nucleon (1,SOA)	Measures elemental, isotopic compositions, energy spectra and angular distributions. Five separate experiments (1,SOA).
Solar Wind Experiment	Solar wind electrons protons and ions	Electrons energy range of 0.5 eV to 1.6 keV (1,SOA); ion energy range of 50.0 eV to 1.6 keV per unit charge (1,SOA)	Gives particle velocity, arrival direction, flux and mass per unit charge. Three electrostatic analyzers with continuous electron multiplier detectors (1,SOA).
Magnetometer	Interplanetary and Jovian magnetic field vector	Range of 0.01 nT to 65 μT with 0.025% resolution at 20 vectors/sec (1,SOA)	Observe spatial, temporal variation in magnetic fields. Two triaxial fluxgate magnetometers mounted on boom (1,SOA).
Unified Radio and Plasma Wave	Ambient, solar and Jovian electromagnetic waves	Spectral range of 1.5 kHz to 1 MHz in 16 channels (1,SOA)	Determine source locations. 100 m dipole antenna, broadband RF receiver (1,SOA).
Interstellar Gas and UV Photometer	Photons emitted by H and He and He particles	Photometers for 122 nm (H) and 58 nm (He) (1,SOA)	Measure density of neutral interstellar He and its interaction with solar system.
Zodiacal Light	Brightness and polarization of sunlight scattered by dust.	Spectral range of 220 to 840 nm in six 50 nm bands (1,SOA)	Use brightness, color and polarization to determine distribution and properties of dust.

MISSION: SOLAR OPTICAL TELESCOPE (SOT) S-4

Status:	Approved
Lifetime:	10 years
Launch and Transfer Vehicles:	Shuttle/Spacelab
Operational Location:	460 km at 57 deg.
Total Mass at Operational Location:	3100kg for first flight
Average Operational Power:	935w



OBJECTIVE: The scientific objective of the SOT is to obtain high resolution data which are required to solve many fundamental problems in solar physics. These problems include the energy and mass transports in the solar atmosphere in the presence of magnetic fields, the origin and evolution of the surface magnetic fields, the nature of sunspots and prominence, and many phenomena known to occur in laboratory plasmas, believed to be present on the sun (fluxes), but, heretofore not yielding to instruments of coarser resolution than the SOT.

DESCRIPTION: SOT is being developed for NASA's Solar Terrestrial Programs and is to be integrated with the NASA European Space Agency (ESA) Spacelab Program and will utilize the ESA Instrument Pointing System (IPS) for arc-second pointing and stability. A parabolic primary mirror, 1.25m aperture f/3.6, will provide diffraction limited solar imaging in the spectral region 115 nm to 1000 nm. An articulated primary mirror actuator assembly will provide active alignment, focus, sub-arc second pointing, rastering, and up to ± 1/2 degree offset. SOT as the baseline facility, will accommodate various Science Instruments (SIs) at its focal plane. First flight is planned for 1984. The basic telescope with additional and/or modified instruments is expected to be used for many Shuttle/Spacelab missions. An interactive interface will be provided between the SOT and the trained observers. Control and operation of the SOT will conform to an established mission operations plan; however, targets of opportunity will arise and the interactive control will allow decisions by the observers to be implemented. The observers include the Mission/Payload Specialists (crew) and the scientists in the Payload Operations Control Center (POCC).

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT: For the first flight of SOT, the strawman payload studied by the Facility Definition Team consists of a universal filter polarimeter (UFP), a stigmatic ultraviolet spectrograph (UVS), and a visible light Schmidt spectrograph.

REFERENCES: Solar Terrestrial Mission Concept: Solar Optical Telescope 1, NASA, July 1979.

CONTACTS: Ewaldt Schmidt, GSFC, (301)344-7638

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR OPTICAL TELESCOPE S-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	7.3x3.9 (dia)	1, SOA	
Total Mass (kg)	3100	1, SOA	Weight of Evolutionary SOT is expected to increase to 6600 kg.
Mass breakdown (kg)			
Basic Structure	1200		
Enclosure	300		
Primary Mirror	780		
Gregorian Pod	50		
Electronics	30		
First Flight Inst.	740		
Deployed/articulated items, size (m)			
Aperture cover	1.25	1, SOA	
Primary Mirror	1.25 (dia)	1, SOA	SOT itself is deployed and pointed by the ESA Instrument Pointing System. Articulated primary mirror provides fine pointing, rastering and offsets.
Life			
Flight duration (days)	7-21	1	Each Spacelab/SOT mission lasts 7 to 21 days. SOT is returned, refurbished and reflown about 1 year later. A useful life of 10 years is planned.
Number of spacecraft	1	1	
Orbit			
Periapse/apoapse altitudes (km)	460	1	High inclination orbits are desirable for continuous solar observations.
Inclination (deg)	57	1	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR OPTICAL TELESCOPE S-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	1	For the first flight it is assumed that in the data taking mode, the scientific data are recorded primarily on film. Engineering data and housekeeping information are monitored on board, recorded on tape and, at opportune intervals, telemetered to the ground via TDRSS. Shuttle/Spacelab systems are utilized.
Storage			
Capacity (bits)	NA		
I/O rates (kbps)	NA		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	1	
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	1	
Communications			
Minimum/maximum downlink rates (kbps)	ND	1	Data communications via TDRSS handled by Shuttle systems. Digital data used for housekeeping; voice link used for communication between payload specialist and POCC.
Guidance & Attitude Control			
View direction	Sun	1, SOA	It is assumed that the Orbiter and Instrument Pointing System serve as a "Coarse" Pointing System and that an internal SOT pointing system will achieve the necessary fine pointing(0.02 arc sec). Gravity-gradient or quasi-inertial attitude modes for the orbiter are desirable to reduce effects on SOT pointing and RCS propellant usage. Fine pointing sensor is not defined.
Position accuracy (km)	ND	1	
Pointing accuracy (mrad)	10^{-4}	1, SOA	
Stability (mrad)	10^{-4}	1, SOA	

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR OPTICAL TELESCOPE S-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	935	1, SOA	Power comes from Shuttle/Spacelab; requirement applies to first flight SOT mission. Evolutionary SOT missions may require additional power. Power is presently limited by IPS gimbal constraint.
Peak power consumed (We)	ND	1, SOA	
Power breakdown (We)			
SOT Electronics	100	1, SOA	
SOT Thermal Control	450		
First Flight Inst.	385		
Energy Storage			
Storage capacity (J)	NA		
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
Support Truss	293	1, SOA	The thermal control system required to maintain first flight alignment tolerances is assumed to be primarily passive. (i.e., insulation and thermal coatings) Primary mirror must have low thermal gradients. Replacement heaters may be used to warm structure and primary mirror. Heat rejection mirrors reflect unwanted solar energy back through aperture.
Primary Mirror	293	2, SOA	
Heat Rejection Mirr.	293	2, SOA	
Component load (Wt)			
Support Truss	400	1, SOA	
Primary Mirror	ND	1, SOA	
Heat Rejection Mirr.	ND	1, SOA	

SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

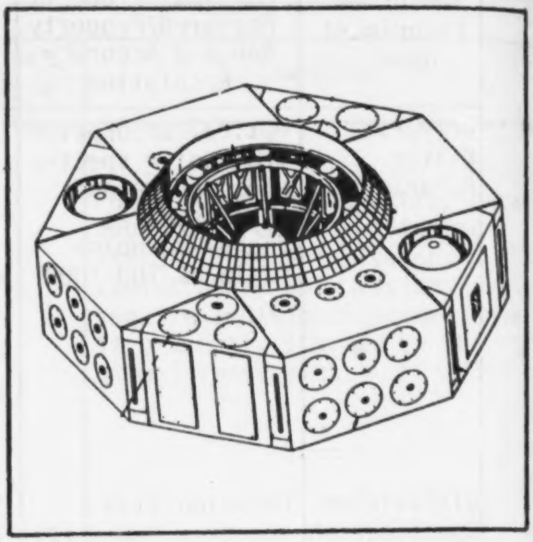
MISSION: SOLAR OPTICAL TELESCOPE S-4

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Universal Filter Polarimeter	Optical absorption from solar spectra photosphere and chromosphere; signal-to-noise ratio of 100-1000.	Spectral range 500 to 680 nm (1,SOA) with future improvement to 400-1100 nm. Spectral resolution is 0.006 nm. Angular resolution of 0.1 arc sec; magnetic field range of 2-3000 Gauss; velocity range of 5-200 m/sec. (1,SOA)	The UFP provides narrow-spectral-bandwidth filter grams in polarization analyzed light of the solar photosphere and chromosphere allowing measurement of magnetic and velocity fields. Film used to record images although a silicon photo-electric detector is needed for higher SNR.
Ultraviolet Spectrograph	Emission line spectra; intensity resolution of 15%.	Spectral range of 120 to 200 nm (1,SOA) with resolution of 0.001 to 0.005 nm (3,EV). Angular resolution of 0.1 arc sec; temporal resolution of 1 to 60 sec (3,EV)	The UVS studies the structure and dynamics of the chromosphere and transition zone. Emission lines are measured with moderate spectral resolution as functions of time and position. Sensor is film.
isible ight pectrograph	Absorption spectrum of solar photosphere; intensity resolution of 15%.	Spectral range of 270 to 1100 nm with resolution of 0.001 nm (2,EV). Angular resolution of 0.1 arc sec; temporal resolution of 0.5 to 20 sec.	Schmidt spectrograph used to study the production, propagation and dissipation of magneto-mechanical waves in the solar atmosphere and the influence of the convection zone on the upper adjacent atmospheric layers that are in radiative equilibrium. Film used to record spectra.

SOLAR TERRESTRIAL

MISSION: CHEMICAL RELEASE MODULE FACILITY S-5

Status:	Approved
Lifetime:	6 months
Launch and Transfer Vehicles:	Shuttle plus kick motor
Operational Location:	Earth orbit at 250 to 1200km altitudes
Total Mass at Operational Location:	2700kg
Average Operational Power:	20w



OBJECTIVE: The Chemical Release Module (CRM) facility will have the capability of multiple releases of liquids and gases onto the magnetosphere/ionosphere system. The releases are used to trace the motions of neutral gases, plasmas and energetic particles and to map magnetic and electric fields.

DESCRIPTION: The CRM is being developed for NASA's Solar Terrestrial Program with a first flight set for 1983. The expendable module is carried into orbit by Shuttle/Spacelab and is deployed into a free-flying orbit. Orbit apoapse is raised to 1200 km by a kick motor. Later missions might use the SUSS-A or -D for a higher apoapse (up to 25 Earth radii). Chemicals are released on command from the ground through TDRSS or STDN. Each release is to be observed by ground-based facilities, aircraft, existing spacecraft, and in some cases, by Shuttle/Spacelab instruments.

CRITICAL TECHNOLOGY NEEDS: Canisters for impulsive release of large amounts (≈500kg) of liquids or gases for producing significant pertubations of the ambient medium.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Thermite Metal Vapor Cannisters
Pressurized Gas Cannisters
Liquid Expulsion Cannister
Shaped Charged Devices

REFERENCES: "Chemical Release Module - A Multi-user Facility for Shuttle Spacelab" Report of the AMPS Chemical Release Facility Definition Team, Goddard Space Flight Center, March 1978

CONTACTS: L. Richards, MSFC, (205)453-0461

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: CHEMICAL RELEASE MODULE FACILITY S-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	2x3(dia)	1, SOA	
Total Mass (kg)	2700		
Mass breakdown (kg)			
Power System	ND		
Deployed/articulated items, size (m)	NA		
Life			
Flight duration (days)	180		Additional missions launched at approximately 2 year intervals.
Number of spacecraft	1-3		
Orbit			
Periapse/apoapse altitudes (km)	200/1200	1, SOA	This is orbit for first mission. Others may have apoapse of 3-25 Earth radii and may have 28 to 90 deg. inclinations.
Inclination (deg)	57	1, SOA	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: CHEMICAL RELEASE MODULE FACILITY S-5

Mission Parameter (units;	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	7.5x10^5	1, SOA	Based on 1 kpbs, 12.5 minutes per day.
Storage			
Capacity (bits)	ND	1, SOA	Portions of the Multimission Modular Spacecraft Command and Data Handling System will be utilized when appropriate. When other equipment is better suited for the requirements, it will be used.
I/O rates (kbps)	ND		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	1, SOA	
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	1, SOA	Standard POCC services at GSFC will be used to prepare data for delivery of the investigators.
Communications			
Minimum/maximum downlink rates (kbps)	1.0	1, SOA	Digital data (engineering and housekeeping)and commands sent through TDRSS.
Guidance & Attitude Control			
View direction	NA	1, SOA	No attitude control system is planned for first 3 missions. The CRM will be spin-stabilized for injection into eliptical orbit and for thermal and power reasons. Knowledge of altitude to ±2° at point of propulsion motor firing will be determined with ground computers using telemetry data from sun and horizon sensors.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	NA		
Stability (mrad)	NA		

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: CHEMICAL RELEASE MODULE FACILITY S-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	20	3, SOA	Photovoltaic
Peak power consumed (We)	180	3, SOA	
Power breakdown (We)	Avg/Pk		
Transponder	11/37		
Central Unit	5/11		
Remote Int. Unit	2/2		
Pre-Mod Processor	0/7		
Signal Cond. Unit	0/3		
Firing Circuits	0/120		
Energy Storage			
Storage capacity (J)	180	3, SOA	NiCd batteries
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)	ND	3, SOA	We foresee no requirement for state-of-the-art advancement. CRM equipment will utilize proven passive thermal design concepts, a cold bias with electrical heaters to maintain minimum temperature levels.
Component load (Wt)			

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: CHEMICAL RELEASE MODULE FACILITY S-5

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	267.4	1, SOA	Solid propellant kick stage used to raise orbit apoapse to 1200 km.
Thrust level(N)	27090.	1, SOA	
Isp(sec)	290.35	1, SOA	
Propellant mass(kg)	245	1, SOA	
Inert mass(kg)	130	1, SOA	

SOLAR TERRESTRIAL

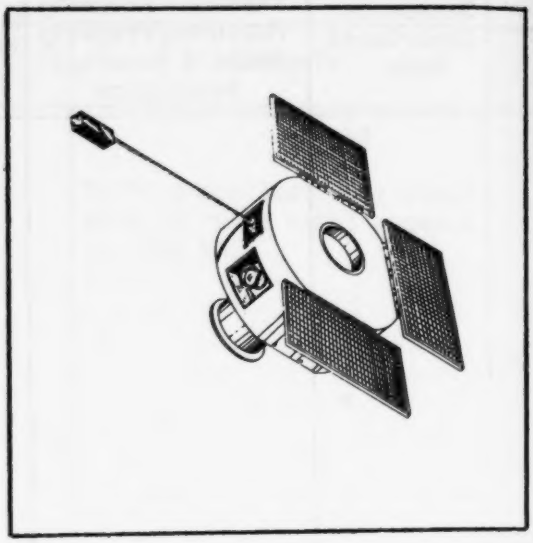
SENSOR/EXPERIMENT PARAMETERS

MISSION: CHEMICAL RELEASE MODULE S-5

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
NA			Observations of chemical releases will be from ground-based facilities, aircraft, other satellites and/or Shuttle/Spacelab using standard instruments such as film cameras, TV cameras and sounding radars. All instrumentation is well within the SOA.

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPERIMENT

Status:	Planned
Lifetime:	1 year
Launch and Transfer Vehicles:	Shuttle/SUSS-D
Operational Location:	Earth orbit with 300km perigee
Total Mass at Operational Location:	670kg
Average Operational Power:	120w



OBJECTIVE: The Active Magnetospheric Particle Tracer Experiment (AMPTE) is designed to study the question of access of solar wind ions to the magnetosphere, the convective--diffusive transport and energization of magnetospheric particles and the elemental and charge composition of magnetospheric ions.

DESCRIPTION: AMPTE is a proposed international cooperative project between NASA/GSFC and BMFT/DFVLR (West German Government). NASA will provide a Charge Composition Explorer (CCE) Spacecraft and Germany will provide an Ion Release Module (IRM) for a Shuttle launch in September 1983. The Charge Composition Explorer will be launched from the Kennedy Space Center (KSC) into an elliptic orbit 7 R_e apogee and 300 km perigee. The IRM will be launched "piggy-back" on the same Shuttle/SUSS-D vehicle with an additional kick-stage into an elliptic orbit of 19 R_e apogee and 300 km perigee. Soon after the autumnal equinox the first ion release will be made from the IRM. The CCE will detect the ions as they enter through Earth's magnetosphere. Two or more additional ion releases will be made later on in the mission within the magnetosphere to further study the solar wind interaction with the magnetosphere. This project is planned for FY 81.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: The instrument complement of the CCE comprises a low energy spectrometer, a medium energy solid state detector system, and a Mass-Energy instrument for coverage of intermediate energies. The IRM has three or more release canisters and attitude sensors.

REFERENCES: "Interim Study Report for AMPTE", Johns Hopkins University Applied Physics Laboratory and Max-Plank-Institute for Physik and Astrophysik, Institute for Extraterrestriche Physik, February 1977.

CONTACTS:
Gilbert W. Ousley, GFSC, (301)344-8073
Stamatios Krimigis, APL, (301)952-7100 x3252

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPERIMENT S-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	1.1x3 (dia)	3, SOA	For CCE; IRM is 1.2 x 2.0 (dia)
Total Mass (kg)	770	3, SOA	
Mass breakdown (kg)			
CCE	120		
IRM	550		
Deployed/articulated items, size (m)			
Solar Array(CCE)	ND		
Deployable Cannisters (IRM)	ND		
Life			
Flight duration (days)	365	3, SOA	
Number of spacecraft	2		One CCC and one IRM
Orbit			
Periapse/apoapse altitudes (km) Inclination (deg)	See Comments	3, SOA	CCE orbit is 300 km perigee and 7 Earth radii apogee at about 0 deg. inclination. IRM orbit is also 300 km perigee, 19 R_e apogee at 28.5 deg. inclination.

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPERIMENT S-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	$8x10^6$	3, SOA	Requirement stated is for CCE; IRM requirement is not determined.
Storage			
Capacity (bits)	$8.8x10^7$	3, SOA	Tape recorder for CCE.
I/O rates (kbps)	1-120		
Spacecraft processors/ computers			
I/O rates (kbps)	ND		
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND		
Communications			
Minimum/maximum downlink rates (kbps)	1-120	3, SOA	S-band link to DSN used for CCE's digital data.
Guidance & Attitude Control			
View direction	ND	3, SOA	Both spacecraft, CCE and IRM, are spin-stabilized. There are sensors, (magnetometer and Sun sensor) to determine attitude. Pointing accuracy of about 3 deg. required when propulsion systems are used for orbit adjustments.
Position accuracy (km)	ND		
Pointing accuracy (mrad)	ND		
Stability (mrad)	ND		

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPERIMENT S-6

Mission Parameter (units)	Value	Confidence Level, echnology State	Comments
Power			
Average power consumed (We)	90/30	3, SOA	Both CCE and IRM use photovoltaic power sources CCE requirement is 90 w; 140w is available. IRM requirement is about 30w.
Peak power consumed (We)	ND		
Power breakdown (We)	ND		
Energy Storage			
Storage capacity (J)	8.5×10^6	3, SOA	Both spacecraft will have NiCd batteries (84-Ah capacity for CCE).
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)	ND	3, SOA	Passive methods (coatings and insulation) are thought to be sufficient.
Component load (Wt)			

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACE EXPERIMENT S-6

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3, SOA	SUSS-D used to raise apogee of IRM and [illegible]E from 300 km Shuttle orbit to [illegible] R_e.
Thrust level(N)	2613	3, SOA	Solid propellant motor raises apogee of IRM orbit from 7 R_e to 19 R_e.
Isp(sec)	276		
Propellant mass(kg)	87		
Inert mass(kg)	9		
Second Stage Parameters			
Thrust level(s)	378	3, SOA	Solid propellant motor to change CCE orbit inclination from 28.5 deg. to 0 deg.
Isp	275	3, SOA	
Propellant mass(kg)	31		
Inert mass(kg)	5		

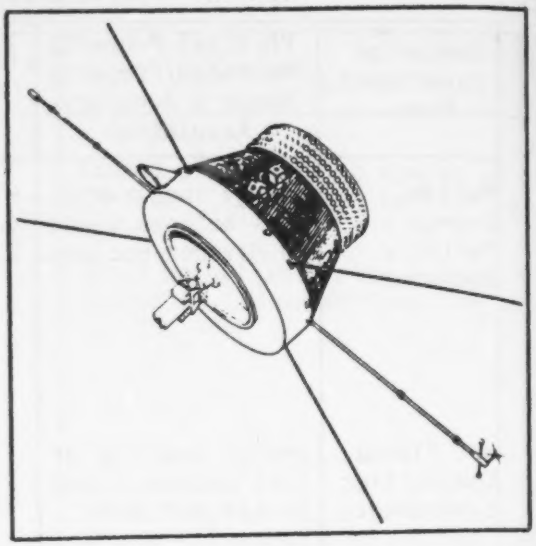
SENSOR/EXPERIMENT PARAMETERS

MISSION: ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPERIMENT S-6

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Medium Energy Particle Detector	Energy spectrum of ions between 0 and 20 Mev per nucleon.	Flux of 10^{-4} to 3×10^8 $(cm^2 \text{ sec ster})^{-1}$ for $Z \geq 3$. (3,SOA)	Detect Li ions from chemical release over a wide energy range in the presence of an intense background of protons, alphas and electrons. Instrument is solid state detector telescope.
Hot Plasma Composition Experiment	Energy spectrum of ions between 0 and 17 keV per unit charge		
Charge-Energy-Mass Spectrometer	Energy spectra of ions between 0.5 and 350 keV per unit charge		

MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD (OPEN)

Status:	Planned
Lifetime:	4 years
Launch and Transfer Vehicles:	Shuttle/SUSS-A for each of 4 spacecraft
Operational Location:	(See Description)
Total Mass at Operational Location:	1000kg each
Average Operational Power:	145w each



OBJECTIVE: The OPEN mission is a key element in NASA's program to understand solar-terrestrial relations. Its objectives are to determine the energy flow through the coupled heliosphere-magnetosphere-ionosphere system; to provide our understanding of plasma processes that are important in controlling the Earth's nearby space environment and, to trace their cause and effect relationships on a global scale; and to assess the importance to the terrestrial environment of variations in energy input to the Earth's atmosphere that are caused by heliospheric or magnetospheric plasma processes.

DESCRIPTION: The OPEN mission is being planned by NASA's Solar Terrestrial Programs as a FY 81 new start. The four spacecraft are an Interplanetary Physics Laboratory (IPL) to be stationed in the upstream solar wind at the sunward libration point, a Geomagnetic Tail Laboratory (GTL) which uses lunar swingbys to maintain an apogee of 80 to 240 R_e in the magnetotail, a Polar Plasma Laboratory (PPL) in an eccentric polar orbit apogee of 15 R_e, and a Equatorial Magnetospheric Laboratory (EML) in an eccentric equatorial orbit with an apogee of 12 R_e. The four spacecraft are to be launched over a 12-month period in 1985 and/or 1986. The spacecraft share a common basic design based upon similar complements of instruments and mission orbit requirements. Observations with the four spacecraft are to be coordinated with each other and with ground-based research programs for magnetic field, ionospheric and auroral observations.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Tentatively each spacecraft carries instruments to measure magnetic field, plasma waves, energetic ions and energetic electrons. One or more spacecraft also measure DC electric fields, solar wind plasmas, hot and cold plasmas and auroral images.

REFERENCES: Origin of Plasmas in the Earth's Neighborhood--Final Report of the Science Working Group, NASA/GSFC, April 1979.
Preliminary, Execution Phase Project Plan for Origin of Plasmas in the Earth's Neighborhood, NASA/GSFC, September 1979.

CONTACTS: J. Alexander, NASA/GSFC, (301)344-5461
J. Longanecker, NASA/GSFC, (301)344-7751

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD (OPEN) S-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	3.5x3.0 (dia)	3, SOA	The OPEN series of spacecraft are nearly identical in design concept. The GTL and IPL spacecraft are right cylinders measuring 2.2mx2.0m (dia) with body mounted solar cells. The PPL and EML spacecrafts are variations of GTL and IPL employing body mounted solar arrays on truncated conical surfaces. The dimensions of these spacecrafts are approximately 3.5mx3.0m (dia).
Total Mass (kg)	1000	3, SOA	
Mass breakdown (kg)			
Science Instruments	100		
Propellant	500		
Deployed/articulated items, size (m)			
Magnetometer booms	2-3	3, SOA	
Antennas	2-3	3, SOA	
Life			
Flight duration (days)	1460	2, SOA	First two launches simultaneous, then two more at 6-month intervals.
Number of spacecraft	4		
Orbit			
Periapse/apoapse altitudes (km)	See Comments	2, SOA	IPL is an heliocentric orbit at sunward libration point. EML and PPL have altitude ranges of 2 to 15 Earth radii and inclination of 0° and 80°; GTL uses multiple lunar swingbys at 1-4 mo. intervals with 5 to 15 lunar radii encounter distance.
Inclination (deg)			

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD (OPEN) S-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	0.2 to 2 x 10^9	3, SOA	
Storage			
Capacity (bits)	ND	3, SOA	NASA standard tape recorder.
I/O rates (kbps)	4-100		
Spacecraft processors/ computers			Real-time and delayed execution commanding. Store one day's commands. Conventional analog multiplexer. Most instruments will contain onboard data processing.
I/O rates (kbps)	ND		
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	8×10^6	3, SOA	Collect, coordinate data from 4 spacecraft. Generate data base and store on tape. Network to communicate data to investigators.
Communications			
Minimum/maximum downlink rates (kbps)	100-600	1, SOA	Recorded digital data to DSN using S-band transmitter. Also real-time data at 6 kbps and tracking data using S-band transponder.
Antenna Gain(db)	14-20	2, EV	Basic technology exists, but mission unique antenna not developed or space qualified.
Guidance & Attitude Control			Spin-stabilized with passive nutation damper. Spin rates of 5 to 100 RPM. Three have spin axis normal to orbit plane--one parallel to orbit plane. Acceleromete measures and controls velocity increment during orbit adjust. Use solar and stellar position sensors to obtain orientation data with 0.1 degree accuracy. PPL and EML spacecraft require despun platform for some science instruments. Spin rate and spin axis orientation adjustments made with small hydrazine thrusters.
View direction	Varies	3, SOA	
Position accuracy (km)	NA	3	
Pointing accuracy (mrad)	2	3	
Stability (mrad)	NA	3	

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD (OPEN)

S-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	150	3, SOA	The power system will be a Direct-Energy-Transfer (DET) power system using body mounted solar panels. Two solar array configurations are employed: a cylindrical array for IPL and GTL and a truncated array for EML and PPL.
Peak power consumed (We)	ND		
Power breakdown (We)	ND		
Energy Storage			
Storage capacity (J)	2×10^6	3, SOA	Battery will probably be NiCd or Ag-Cd. Also used to filter 28V power supply.
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)	ND	3, SOA	Thermal control of spinning spacecraft with body mounted solar cells is easily accomplished with passive means. Some science instruments may require heaters.
Component load (Wt)	ND		

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD (OPEN)

S-7

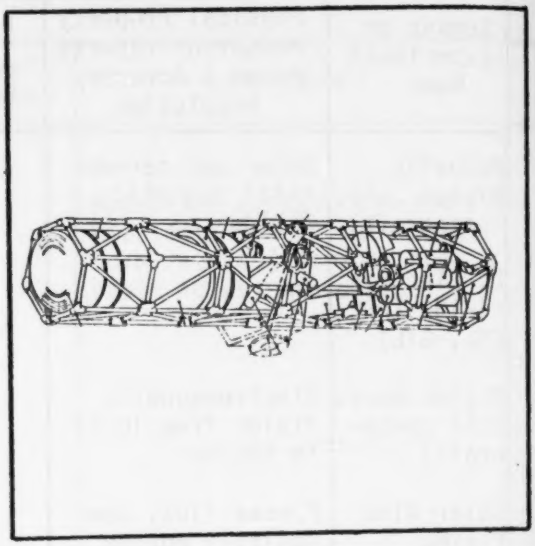
Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	1200	3, SOA	Hydrazine system required for reorientation of spin axis, spin rate adjustments and orbit adjust maneuvers.
Thrust level(N)	25-1000	3	
Isp(sec)	225	3	
Propellant mass(kg)	500	3	
Inert mass(kg)	ND	3	

SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS
MISSION: ORIGIN OF PLASMA IN THE EARTH'S NEIGHBORHOOD S-7

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Magnetic Fields (all spacecraft)	Solar and terrestrial magnetic fields		This list of instruments is tentative, pending evaluation of proposals submitted in response to Announcement of Opportunity issued in October 1979. The instrumentation for the individual spacecraft are different due to the vastly different field, plasma and particle environments encountered.
DC Electric Fields (PPL, EML, GTL)			
Plasma Waves (all spacecraft)	Electromagnetic fields from 10 Hz to 500 kHz.		
Solar Wind Plasma (IPL, GTL)	Plasma flux, composition energy for 0.2 to 50 keV		
Hot Plasma (PPL, EML, GTL)	Plasma flux composition (1 eV to 50 keV)		
Energetic Ions (all spacecraft)	Ion flux composition energy from 0.1 to 20 MeV/AMU		
Energetic Electrons (all spacecraft)	Flux, energy of electrons from 15 to 1000 keV		
Cosmic Rays (IPL)	Cosmic ray flux, composition energy from 1 to 300 MeV/AMU		
Auroral Imager (PPL)	Line emission from aurora	UV, visible and x-ray wavelengths.	

MISSION: SOLAR SOFT X-RAY TELESCOPE FACILITY S-8

Status:	Planned
Lifetime:	5 years
Launch and Transfer Vehicles:	Shuttle/Spacelab
Operational Location:	430km circular orbit at 57 deg.
Total Mass at Operational Location:	1300kg
Average Operational Power:	240w



OBJECTIVE: The Solar Soft X-ray Telescope Facility has as its purpose fundamental observations of the outer solar atmosphere. Specific objectives are to determine the mass flow and energy deposition in the corona, to understand the formation and evolution of coronal features and their relationship to changes in the photosphere and chromosphere, to identify the sites and processes that produce solar flares, and to assess the relationships between the large scale structures of the corona and solar magnetic fields and the interplanetary solar wind and magnetic sector structure.

DESCRIPTION: The Solar Soft X-ray Telescope Facility is being studied as a candidate Shuttle/Spacelab payload to be launched in 1987; a new start in FY 84 is assumed. Instruments for the telescope facility are to be selected by the Announcement of Opportunity process. The telescope consists of a set of confocal mirrors of the Wolter type I configuration for observations from 0.175 to 10nm. A smaller telescope, coaxial and confocal with the larger telescope, will provide imaging at short wavelengths. A spatial resolution of 0.5 arc sec is desired. An evolutionary program of Shuttle flights is planned for the Facility using increasingly sophisticated focal plane instrumentation. The Facility will be mounted on pallets in the Shuttle bay and pointed to the Sun by the ESA Instrument Pointing System (IPS). Data from the observations will either be recorded on film or telemetered to Earth via the Shuttle/Spacelab Command and Data Management System (CDMS) and the Tracking and Data Relay Satellite System (TDRSS).

CRITICAL TECHNOLOGY NEEDS: The nested set of coaxial confocal mirrors of Wolter type I. An outer diameter of 80cm, an area of 1000 cm^2, angular resolution of 0.5 arc sec and spectral range of 0.175 to 10nm are nominal requirements.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Tentative list includes crystal spectrometers, broadband filters, grating spectrometers, boresight monitor, film camera, and photoelectric camera.

REFERENCES: "Interim Reports of the Solar Physics Spacelab Facility Definition Teams", GSFC, July 1975
"Preliminary Definition Study for a Soft X-ray Telescope Facility for Shuttle/Spacelab", American Science and Engineering, Inc., May 1976.

CONTACTS: G. Stouffer, GSFC, (301)344-8346
C. Stout, GSFC, (301)344-8566

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR SOFT X-RAY TELESCOPE FACILITY S-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	6x1.2 (dia)	3	
Total Mass (kg)	1300	3	
Mass breakdown (kg)			
Mirror Assembly	446	3, EV	Assuming invar mirrors, 695Kg if fused quartz.
Optical Bench	180	3	
Focal Plane Assembly	157	3	
Focal Plane Inst.	180	3	
Central Electronics	122	3	
Deployed/articulated items, size (m)			Entire telescope is deployed from Spacelab pallet and pointed at Sun using the ESA Instrument Pointing System.
Life			
Flight duration (days)	7-30	3	Total useful life of about 5 years with additional flights at 6-12 month intervals.
Number of spacecraft	1-2	3	
Orbit			
Periapse/apoapse altitudes (km)	430	3	Launch date selected for maximum solar viewing time (December or June).
Inclination (deg)	56	3	

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR SOFT X-RAY TELESCOPE FACILITY S-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3	Film may be used by some instruments.
Storage			
Capacity (bits)	ND	3	Would use Spacelab tape recorder.
I/O rates (kbps)	ND	3	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3	Would use Spacelab Command and Data Management System.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	
Communications			
Minimum/maximum downlink rates (kbps)	ND	3	Digital data sent using Shuttle/ Spacelab S- or K-band links via TDRSS.
Guidance & Attitude Control			
View direction	sun	3,SOA	Telescope has fine Sun sensor to control IPS. IPS is three-axis gimballed pointing system which should be able to meet pointing accuracy/stability requirements.
Position accuracy (km)	ND		
Pointing accuracy (mrad)	.005		
Stability (mrad)	.001		

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR SOFT X-RAY TELESCOPE FACILITY S-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	240	3	Power provided by Shuttle/ Spacelab through IPS interface.
Peak power consumed (We)	360	3	
Power breakdown (We)			
Photoelectric camera	30	3	
Grating Spectrometer	80	3	
Thermal Control Sys.	70	3	
Energy Storage			
Storage capacity (J)	NA		
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)	ND		
Component load (Wt)	ND		

SOLAR TERRESTRIAL

SENSOR/EXPERIMENT PARAMETERS

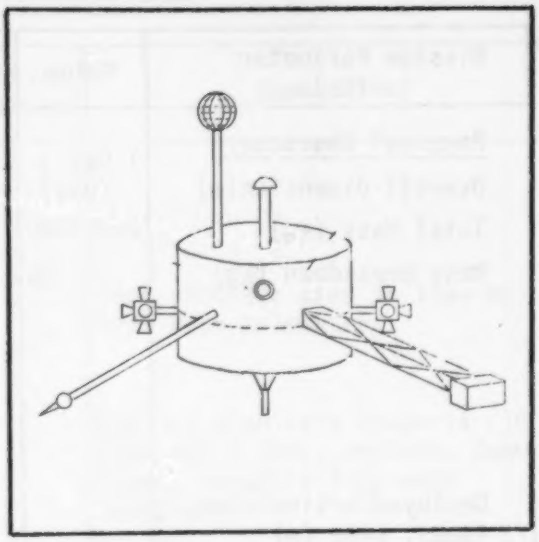
MISSION: SOLAR SOFT X-RAY TELESCOPE FACILITY S-8

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Filtergrams	Solar X-ray emission	Angular resolution of 0.5 arc sec, time resolution of 1 sec, spectral range of 0.175 to 7.5nm, and spectral resolution of 16%	Full disk images of the Sun in broad X-ray bands.
Objective Grating Spectrometer	Solar X-ray emission spectrum	Angular resolution of 0.5 arc sec, time resolution of 1 sec., spectral range of 0.6 to 7.5nm with 1% resolution or better	Full disk coverage of the Sun with sufficient spectral resolution to isolate specific line emission features.
Crystal Spectrometers and Polarimeter	Solar X-ray emission spectrum	Spectral range of 0.175 to 2.5nm with resolution of 10^{-3} to 10^{-4}, spatial resolution of 1 to 10 arc sec, time resolution of less than 1 sec.	Images of selected areas with sufficient spectral resolution that velocity and magnetic fields can be deduced.
Grating Spectrometers	Solar X-ray emission spectrum	Spectral range of 2 to 10nm, others same as crystal spectrometer	Same as crystal spectrometer.

SOLAR TERRESTRIAL

MISSION: SUBSATELLITE FACILITY S-9

Status:	Planned
Lifetime:	ND
Launch and Transfer Vehicles:	Deployed/recovered from Shuttle/Spacelab
Operational Location:	Within 100km of Shuttle
Total Mass at Operational Location:	200-1000 kg
Average Operational Power:	100-200w



OBJECTIVE: The Subsatellite Facility is to provide a platform for plasma diagnosis at locations near the Shuttle/Spacelab. It supports active controlled experiments conducted from Spacelab, carries out in-situ observations free of the contamination induced by Shuttle/Spacelab and performs bi-static optical and radio experiments.

DESCRIPTION: The Subsatellite Facility is being studied for use in NASA's Solar Terrestrial program. The subsatellite must carry sufficient propulsion to be fully maneuverable. It must be compatible with the rest of the Shuttle payload and have the capability for pre-launch checkout of experimental instruments and baseline housekeeping systems. It will be launched and retrieved by the Shuttle and will have a mission lifetime of 7 to 30 days. During the mission, there must be man-in-the-loop control of the satellite and its instruments via the Shuttle aft flight deck or the payload operations control center. First use is currently planned for 1986 if the project starts in FY 83. Up to six subsatellites are to be built and reuse is planned.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: The subsatellite must carry instruments to measure electric and magnetic fields, electromagnetic waves from VLF to VHF, charged particles from thermal energy to very high (>30keV), and neutral atmospheric composition. Optical detectors and retroreflectors are also needed.

REFERENCES:

CONTACTS: R. Bensen, GSFC, (301)344-7511

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SUBSATELLITE FACILITY S-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	1.0x1.5 (dia)	3	Deployed items must extend and retract or be jettisoned.
Total Mass (kg)	200-1000	3	Includes 50-200 kg for science instruments.
Mass breakdown (kg)	ND		
Deployed/articulated items, size (m)			
Science booms	3-6	3, SOA	For magnetic field detectors.
Antennas	10	3, SOA	For electric field detectors.
Science Scan Platform	ND	3	50 kg capacity
Life			
Flight duration (days)	7-30	3	Recovered, reflights planned.
Number of spacecraft	1-6		On-orbit storage is an option.
Orbit			
Periapse/apoapse altitudes (km)	Same as Shuttle	3	Detailed probing within 100 km of Shuttle; drift to 5000 km range possible.
Inclination (deg)			

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SUBSATELLITE FACILITY S-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^9	3	
Storage			
Capacity (bits)	10^{10}	3, SOA	Tape recorder used in lieu of high rate telemetry.
I/O rates (kbps)	256		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, EV	Low and high rate channels (16 kbps and 1 Mbps) desired; functional compatibility with Spacelab.
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	3, EV	Real-time control of satellite position relative to Shuttle from aft flight deck or POCC; real-time data processing and display.
Communications			
Minimum/maximum downlink rates (kbps)	See Comments	3, EV	Subsatellite data is both digital and analog(video). Data/commands sent over S-band link between Shuttle and subsatellite. (Shuttle sends data to POCC via TDRSS.) Rate desired is 256 kbps at 100 km range--a substantial increase over previous subsatellites.
Guidance & Attitude Control			
View direction	Varies	3, SOA	Three-axis stabilized to about 1 deg. with past-mission knowledge of 0.1 deg. Position with respect to Shuttle must be known with precision of 1 m within 1 km and 200 m for ranges greater than 20 km.
Position accuracy (km)	Varies		
Pointing accuracy (mrad)	15		
Stability (mrad)	ND		

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SUBSATELLITE FACILITY S-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	100-200	3, SOA	Source is not determined.
Peak power consumed (We)	ND		
Power breakdown (We)	ND		
Energy Storage			
Storage capacity (J)	ND	3, SOA	Batteries may be used depending on power source selected.
Discharge rate (We)	ND		
Discharge/recharge times (min)	ND		
Thermal Control			
Component temperature (K)	ND	3	
Component load (Wt)	ND	3	

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SUBSATELLITE FACILITY S-9

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	750	3, SOA	Used for translation maneuvers relative to Shuttle/Spacelab. Thrust levels are likely to be low. May also be used for attitude control.
Thrust level(N)	ND		
Isp(sec)			
Propellant mass(kg)	ND		
Inert mass(kg)	ND		

SOLAR TERRESTRIAL

SENSOR/EXPERIMENT PARAMETERS

MISSION: SUBSATELLITE FACILITY S-9

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Fields	Magnetic and DC electric fields	Also direction of fields	Triaxial fluxgate sensor mounted on a boom; three (10 m) dipole antennas extending from spacecraft; internal electronics.
Waves	Electromagnetic waves at frequencies from several Hertz to tens of MHz.	Also direction of waves	Search coils and loops for magnetic sensors; dipoles for electric fields; VLF receiver with 200 steps between 10 Hz and 30kHz (3,SOA); HF sounder (to sound local plasma resonances); VHF antenna and transmitter/receiver to operate with similar Shuttle/Spacelab system.
Energetic Particles	Charged particle fluxes at medium energy (<30keV) and high energy (>30 keV)	Mass and charge resolution of unit mass and charge.	Medium energy ions and electrons recorded by channeltron arrays at different pitch angles with respect to magnetic field vector. High energy particles measured with solid-state detector arrays at 3 pitch angles.
Plasmas	Plasma density, energy, composition	Also direction	Langmuir probe, ion mass spectrometer, retarding potential analyzer.
Neutral Atmosphere	Density, composition of atmospheric gases		Neutral mass spectrometer, Optical resonance experiment.

SOLAR TERRESTRIAL

MISSION: PLASMA TURBULANCE EXPERIMENT S-10

Status: Planned

Lifetime: Not determined

Launch and Transfer Vehicles: Shuttle plus upper stage

Operational Location: Several different plasma regions

Total Mass at Operational Location: Not determined

Average Operational Power: Not determined

OBJECTIVE: The general purpose of this new candidate mission is to investigate and describe the mechanisms of plasma turbulence in the Sun-Earth environment, including deep space as well as near-Earth regions.

DESCRIPTION: Mission concepts are in the formative stage with a Science Panel created in 1979 to investigate science rationale for a mission exploring plasma turbulence. Science requirements/goals will be an output of the panel, and publication is expected in late 1980. Preliminary findings indicate a requirement for multiple spacecraft traveling in both deep space and near-Earth space regions. Temporal and spatial calibration requirements indicate the desirability of tether connected spacecraft and/or instruments.

CRITICAL TECHNOLOGY NEEDS: Tether technology (long length, high strength tethers, tether structures, tether deployment and controlled length change). Additional technologies not yet determined.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Not determined.

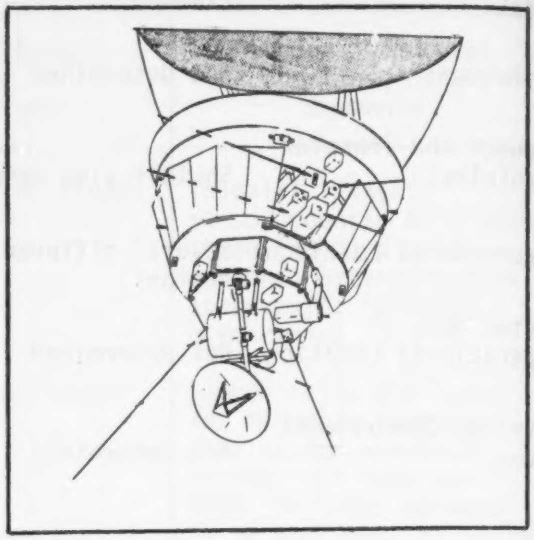
REFERENCES: None.

CONTACTS: R. A. Wallace, JPL, (213)354-6162

SOLAR TERRESTRIAL

MISSION: SOLAR PROBE S-11

Status:	Planned
Lifetime:	5 years
Launch and Transfer Vehicles:	Shuttle/IUS (Twin)
Operational Location:	Heliocentric orbit with perihelion at $4R_{sun}$.
Total Mass at Operational Location:	About 1500kg
Average Operational Power:	About 700w



OBJECTIVE: The Solar Probe mission will be mankind's first direct exploratory venture to the vicinity of the Sun. Scientific objectives include the mechanisms that heat the corona and drive the solar wind, the origin and release of energetic particles, high resolution solar imaging, the gravity field and interior of the Sun, tests of general relativity and a search for gravitational radiation.

DESCRIPTION: This mission for NASA's Solar Terrestrial Programs is being studied as a candidate new start in FY 84 with launch by the Shuttle/IUS in October 1987 on a multiple planet swingby trajectory to the Sun. Both Earth and Jupiter are used for gravity assist. A large (2.5 km/s) space storable propulsion system provides the ΔV for an intermediate (ΔV-EJGA) trajectory which is targeted for an Earth swingby, then a Jupiter swingby. Targeting at Jupiter defines a perihelion (e.g., $4R_S$) and the inclination (e.g., 90°) at the Sun. The spacecraft arrives at perihelion in late 1992 and would return to the Sun every 4 years thereafter. The spacecraft configuration is dominated by a large thermal shield which casts a shadow over the spacecraft. A "drag-free" sensor controls non-gravitational accelerations to an accuracy of $10^{-10}g$ for precision trajectory control and reconstruction.

CRITICAL TECHNOLOGY NEEDS: Heat shield development for ~3000 Sun environment, telecommunications molding for telemetry design concepts, drag-free development for a three-axis stabilized spacecraft with significant mass perturbations.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Drag-free control system, plasma spectrometer, magnetometer, plasma waves, energetic particles, coronal photometer, lyman-alpha spectrometer, dust impact detector, ion composition, magnetograph/doppler/visual telescope, gamma ray detector, hydrogen maser clock with 4-way telecommunications link, x-ray imaging.

REFERENCES: "A Close-Up of the Sun", JPL Publication 78-70, 01 September 1978.
"Solar Probe Mission Options", JPL Publication 660-77, 15 November 1978.

CONTACTS: J. Randolph, JPL, (213)354-2732

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR PROBE S-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	4.4x3.8 (dia)	3	
Total Mass (kg)	1500	3, REV	Launch mass ~4000kg with propulsion module.
Mass breakdown (kg)			
Science Instruments	130	3, REV	
Attitude/control	225	3, REV	
Temp. Control	330	3, REV	
Power	180	3, EV	
Telecom, C&DH	130	3, EV	
Deployed/articulated items, size (m)			
High gain antenna	1	3, EV	Highly articulated
Dipole antennas(2)	10	3, REV	
Main Thermal Shield	3.8	3, REV	
Science Platforms(3)	.5	3, EV	2 spin; 1 articulated
Life			
Flight duration (years)	5	3, EV	
Number of spacecraft	1		
Orbit			
Periapse/apoapse altitudes (km)	See Comments	3	Earth and Jupiter gravity assist to an orbit with a perihelion of 4 solar radii. Nominal inclination is 90 deg. Perihelion date selected after consideration of Earth position for telemetry/science data acquisition.
Inclination (deg)			

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR PROBE S-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	$4x10^8$	3, EV	
Storage			
Capacity (bits)	$2x10^9$	3, EV	Bubble memory
I/O rates (kbps)	100		
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3, EV	Processors for high rate imaging and low rate science and engineering data and instrument control.
Memory size (bits)	ND		
Ground Processors/ computers			
Memory size (bits)	ND	3, EV	Orbit determination; rapid update of optical sequences in response to simultaneous ground/spacecraft observations.
Communications			
Minimum/maximum downlink rates (kbps)	1-10	3, EV	Digital data sent direct to DSN using S- and X-band frequencies. Telemetry coding (PCM/PSK/PM) required to compensate for signal amplitude scintillations caused by the corona.
Other critical parameters			
Doppler accuracy(mm/sec)	0.1	3, REV	
H_2 Maser ($\Delta f/f$)	10^{-14}	3, REV	
Guidance & Attitude Control			
View direction	Sun Nadir	3, EV	3-axis attitude control during solar encounter using NASA STD reaction wheels with advanced CCD star trackers and NASA STD gyros (DRIRU II). Gyrostabilized gimballed science platform.
Position accuracy (km)	100	3	
Pointing accuracy (mrad)	0.3		
Stability (mrad)	0.0015		
Drag-free control	10^{-10}g	3, EV	Integrated attitude/translation thrust system (Hydrazine); unique drag sensor, advanced estimation technology and uniquely instrumented spacecraft for self-gravity determination.

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR PROBE S-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	700	3, EV	Radioisotope thermal generators (RTG)
Peak power consumed (We)	700	3	
Power breakdown (We)			
Science	100	3	
Communications	250	3	
Attitude Control	240	3	
Energy Storage	NA		
Storage capacity (J)			
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
Heat Shield	ND	3, REV	Must withstand Sun at $4R_s$
Mirrors	ND	3, REV	Used to image Sun at $4R_s$
Component load (Wt)			
Heat Shield	ND	3	Very large load
Mirrors	ND	3	Very large load

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR PROBE S-11

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	2750	3	Space storable bipropellant liquid propulsion system. Provides two main velocity impulses as part of trajectory energy increase sequence. Also low thrust, monopropellant (Hydrazine) system for attitude control/translation.
Thrust level(N)	3558	2, EV	
Isp(sec)	365	2, EV	
Propellant mass(kg)	2019	3	
Inert mass(kg)	468	3	

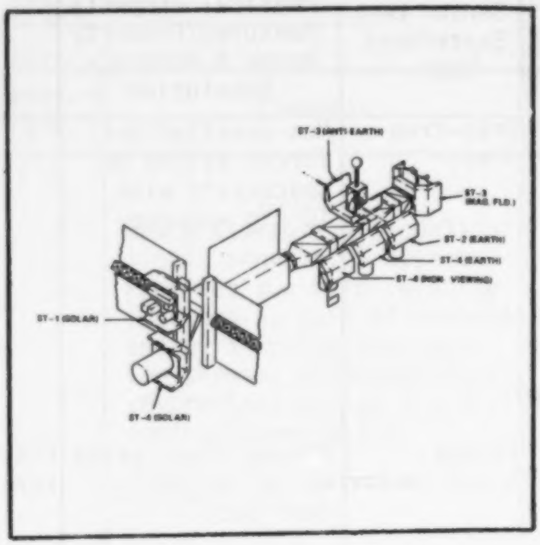
SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: SOLAR PROBE S-11

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Drag-free Sensor	Non-gravitational forces acting on spacecraft with 10^{-10}g accuracy		This sensor is essential for celestial mechanics experiment to determine solar gravity field and test relativity theory. Ball-in-cavity type sensor (3,REV) with complications due to changing spacecraft mass distribution.
Plasma Spectrometer	Plasma flux, range of 10^6 to 10^{14} $(cm^2\ sec)^{-1}$	Plasma velocity of 0-1000 km/sec (2,EV)	In-situ measurement of solar wind and coronal plasma. Electrostatic analyzer with variable aperture for large dynamic range (2,EV).
Magnetometer	Magnetic fields 10^{-2} to 1 Gauss		Flux gate or H_e vector magnetometer to measure field-corona and solar wind. (2,SOA).
Plasma Wave	Electromagnetic fields from 10Hz to MHz	E-field intensity of $3x10^{-6}$ to 5 V/m (3,EV) H-field intensity range is ND.	Electric dipole antenna and search coil to find waves in solar wind and corona. (2,EV). High temperature antenna (2,REV)
Ion Composition	Mass, energy and charge of positive solar ions		Electrostatic accelerator, mass spectrometer and solid-state detector (2,EV).
Magnetograph/ Doppler/ Visual Telescope	Solar images with spectral resolution	Magnetic field of 0.1 to 2000 Gauss (3,REV) Velocity range is ND.	Magnetic field, velocity determined from line profiles. Uses highly selective spectral filter (e.g., Fabry-Perot) and CCD optical detector array. (3,REV).
Hydrogen Maser/ Tracking	Spacecraft orbit position and velocity (to 1 mm/ sec)	Frequency stability of 1 point in 10^{-14} (3,REV)	Detect solar quadrupole moment, gravity waves and relativity effects. Maser clock (3,REV) and dual band (S&X) transceivers (2,EV) are used.

SOLAR TERRESTRIAL

MISSION: SOLAR TERRESTRIAL OBSERVATORY S-12



Status: Candidate

Lifetime: 5 years

Launch and Transfer Vehicles: Shuttle

Operational Location: 400 km orbit at 57 deg.

Total Mass at Operational Location: Not determined

Average Operational Power: 10.5kw

OBJECTIVE: The objectives of this mission include long-term coordinated studies of the coupling between sun-magnetosphere-ionosphere-atmosphere. Additional studies are to be conducted using "Spacelab class" instruments, solar, magnetospheric, ionospheric, and atmospheric phenomena.

DESCRIPTION: The Solar Terrestrial Observatory is a concept for a mission which NASA might begin after 1985 for launch in the 1990's. It uses the 25kw Power Module for electrical power, communications, attitude control, and other support functions. The Power Module is able to support a diverse complement of "Spacelab Class" scientific instruments to perform multiple/interactive investigations. Subsatellites would be used in conjunction with observatory experiments for measuring the effects of particle and wave injection. The observatory is to be operated in real-time from a ground control center with the option of manned operations when the Shuttle is present or if a habitable module is added.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT: Particle accelerators, wave injectors, solar telescopes (x-ray, UV, optical) particle and field detectors, auroral sensors plus additional supporting techniques.

REFERENCES: "Space Science Platform - UAH Workshop", August 21-25, 1978, S.T. Wu and S. Morgan editors.
"NASA Workshop on S-T Studies from a Manned Space Station, NASA CP-2024, 1977.
"Guntersville Workshop on Solar-Terrestrial Studies", NASA CP-2037, 1977.

CONTACTS: R. Chappell, MSFC, (205)453-3036

SOLAR TERRESTRIAL

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR TERRESTRIAL OBSERVATORY S-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	80x15x9	3, EV	Size of basic power module.
Total Mass (kg)	ND	3	
Mass breakdown (kg)	ND	3	
Deployed/articulated items, size (m)			
Subsatellite	1.5x1 dia	2, SOA	
Mast	50	2, EV	
Antennas	300	2, EV	
Life			
Flight duration(days)	1800	3	
Number of spacecraft	1-2		
Orbit			
Periapse/apoapse altitudes (km)	400	2	Polar orbit should also be considered.
Inclination (deg)	57		

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR TERRESTRIAL OBSERVATORY S-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3	
Storage			
Capacity (bits)	ND	3	Magnetic tape recorder similar to Spacelab.
I/O rates (kbps)	ND	3	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3	Redundant computers for observatory sequencing, data handling; microcomputers for experiments.
Memory size (bits)	10^{10}		
Ground Processors/ computers			
Memory size (bits)	ND	3	Ground processor is transparent with direct output to individual principal investigators; real-time operations; creates data base.
Communications			
Minimum/maximum downlink rates (kbps)	32,000	2, EV	High rate digital data sent at Ku-band via TDRSS; provision for analog and video data is desirable.
Guidance & Attitude Control			
View direction	Several		Multiple view directions (solar, Earth nadir and limb and various directions with respect to magnetic field). Use fine Sun sensor, star tracker, and gyros; maintain inertial attitude with 3 axis control moment gyro (CMG) system. Articulate platforms for atmospheric and particle/ fields experiments.
Position accuracy (km)	1 km	3	
Pointing accuracy (mrad)	3	3, SOA	
Stability (mrad)	0.005	3, EV	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR TERRESTRIAL OBSERVATORY

S-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	10,500	3, EV	Power source is 25 kw power module. Power regulators require phase lock capabilities to aid in control of electromagnetic interference (EMI).
Peak power consumed (We)	25,000		
Power breakdown (We)			
Instruments	5,000		
Systems	4,000		
Energy Storage			
Storage capacity (J)	ND	3	NiCd batteries.
Discharge rate (We)	ND	3	
Discharge/recharge times (min)	ND	3	
Thermal Control			
Component temperature (K)			
Cold Plate	313	2, SOA	Active thermal control for systems and scientific instruments using cold plates, heat exchanger, and radiators. Output temperatures given.
Heat Exchangers	280	3, EV	
Radiators	277	3, EV	
Component load (Wt)			
Maximum	13.5	3, EV	Capacity of active thermal control system.
Nominal	8.5	3, EV	

SOLAR TERRESTRIAL

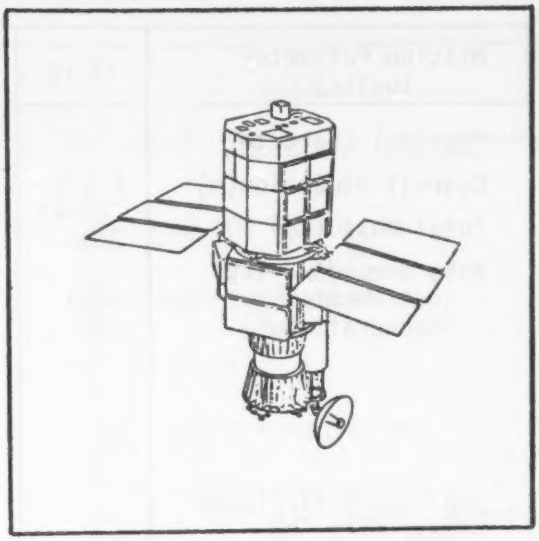
SENSOR/EXPERIMENT PARAMETERS

MISSION: SOLAR TERRESTRIAL OBSERVATORY S-12

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
ND (There will be many experiments)			The experiments used on the Solar Terrestrial Observatory would be selected by the Announcement of Opportunity process. Many selected instruments are likely to be based upon designs proven in Shuttle/Spacelab missions.

SOLAR TERRESTRIAL
MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Status:	Candidate
Lifetime:	2 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	575 km orbit at 28 or 98 deg.
Total Mass at Operational Location:	2600 kg
Average Operational Power:	800 w



OBJECTIVE: The scientific objectives of the Solar Cycle and Dynamics (SCADM) Mission are to measure the large-scale solar magnetic field, its structure and long-term variations; to observe in detail the solar corona, and its time-varying temperature, velocity patterns and density structure; to study global and local oscillations of the solar surface, as a probe of the convection zone; to continue monitoring of the solar constant over a wide spectral range; and to investigate the relationship of these phenomena to each other, to the mechanism of the solar cycle and to events at the earth.

DESCRIPTION: The SCADM spacecraft will be launched by Shuttle into a standard 300 km orbit, then inserted by onboard propulsion into a 575 km circular orbit. This altitude minimizes effects from the radiation belts, yet is above significant extreme ultraviolet (EUV) attenuation. After the two-year mission, enough fuel will remain to allow return to the standard Shuttle orbit for retrieval. Communications will be via the TDRSS. The Multimission Modular Spacecraft (MMS) can be utilized to support the SCADM instruments. The SCADM mission is intended as a follow-on to the approved Solar Maximum Mission. It would be desirable for SCADM to be operational when the International Solar Polar Mission is above the sun's poles in 1986 and 1987. However, this cannot be done because SCADM is being considered for a new start in 1985 at the earliest with launch about three years later. Note that SCADM will be observing a quiet sun whereas SMM observes an active sun.

CRITICAL TECHNOLOGY NEEDS: None, because it is intended that SCADM utilize existing technology (e.g. SMM and MMS) with minor extensions.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Candidate instruments for SCADM are white-light coronagraph, Lyman-alpha coronagraph, extreme ultraviolet spectroheliometer, soft x-ray coronagraph, magnetic field and velocity instrument, solar global-oscillation instrument, solar ultraviolet spectral irradiance monitor, and solar total irradiance monitor.

REFERENCES: Solar Cycle and Dynamics Mission, NASA/GSFC, May 1978.

CONTACTS: D. Suddeth, GSFC, (301) 344-7697

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	6 x 2 (dia)	3	Reconfiguration to reduce use of Shuttle cargo volume is desirable.
Total Mass (kg)	2600	3	
Mass breakdown (kg)			
Instruments	1000	3	
Spacecraft bus	1600	3	
Deployed/articulated items, size (m)			
Solar arrays (2)	1.2 x 1.8	3,SOA	Fixed, like SMM.
TDRSS antenna	1.3 (dia)	3,SOA	Steerable, like SMM.
Life			
Flight duration (years)	2	3,SOA	Longer flight possible with Shuttle retrieval or resupply and refurbishment.
Number of spacecraft	1	3	
Orbit			
Periapse/apoapse altitudes (km)	575	3,SOA	Shuttle deployment in 300 km orbit. Propulsion system used to increase altitude for reduced UV absorption. 28 deg inclination is nominal since it has frequent Shuttle opportunities. 98 deg sun-synchronous orbit is option with continuous solar observations.
Inclination (deg)	ND	3	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	5×10^9	3,SOA	Maximum MMS capability.
Storage			
Capacity (bits)	2×10^9	3,SOA	Two tape recorders.
I/O rates (kbps)	ND	3	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3,SOA	Spacecraft computer has 18 bit/word; is used for sequencing and science/engineering date acquisition via remote interface units.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3,SOA	Dedicated minicomputer at GAFC to control spacecraft and distribute data to experimenters.
Communications			
Minimum/maximum downlink rates (kbps)	ND	3,SOA	Digital data transmitted over S-band link to TDRSS. Desire capabilities for real time data using multiple access mode and recorded data using single access service.
Guidance & Attitude Control			
View direction	Sun	3,SOA	Three-axis stabilized, points at any desired location on the solar disk. Instrument payload has fine sun sensor; spacecraft has gyros, star tracker and coarse sun sensor. Instruments need 1 arc sec pointing stability. Both momentum wheels and hydrazine thrusters are provided for attitude control.
Position accuracy (km)	NA		
Pointing accuracy (mrad)	0.005	3,SOA	
Stability (mrad)	0.002	3,SOA	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	800	3,SOA	Solar cells provide about 1500 w when normal to sun.
Peak power consumed (We)	ND	3	
Power breakdown (We)			
Instruments	200	3	
Engineering subsystems	600	3	
Energy Storage			
Storage capacity (J)	6×10^7	3,SOA	Three 20 Ampere-hour NiCd batteries (for 28 deg inclination orbit)
Discharge rate (We)	800	3	
Discharge/recharge times (min)	30/60	3	
Thermal Control			
Component temperature (K)			
Instruments/subsystems	ND	3,SOA	Sun shade and insulation to reduce solar input; louvers to control heat loss.
Component load (Wt)			
Instruments/subsystems	ND	3	

SOLAR TERRESTRIAL
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	360	3,SOA	Monopropellant hydrazine system used for orbit altitude changes between Shuttle deployment and retrieval at 300 km and operations at 575 km. Also used as attitude control back-up.
Thrust level(N)	ND		
Isp(sec)	225	3,SOA	
Propellant mass(kg)	450	3	
Inert mass(kg)	ND	3	

SOLAR TERRESTRIAL
SENSOR/EXPERIMENT PARAMETERS

MISSION: SOLAR CYCLE AND DYNAMICS MISSION S-13

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
White-light Coronagraph			The list of candidate instruments is tentative pending further studies of the SCADM mission which will provide details on these instruments. The selected instruments may be derivatives of ones flown on the Solar Maximum Mission or on a Spacelab mission.
Lyman-alpha Coronagraph			
EUV Spectroheliometer			
Soft X-ray Coronagraph			
Magnetic Field and Velocity Instrument			
Solar Global Oscillation Instrument			
Solar UV Spectral Irradiance Monitor			
Solar Total Irradiance Monitor			

LIFE SCIENCES

The objectives of the Life Sciences program are to utilize the space environment to advance knowledge in medicine and biology, to ensure human health, safety, well being, and effective performance in space flight, and to gain a better understanding of the origin and distribution of life in the universe. Past investigations have focused on evaluating possible hazards to crew health and on identifying factors that could impair crew performance. The early Shuttle-Spacelab flights will emphasize the investigation and understanding of physiological performance and changes which have been observed in humans who have flown in space, and on the identification and investigation of significant biological phenomena which may occur during and/or after exposure to the space environment. Related Shuttle-Spacelab experiments will exploit the zero-gravity aspects of the space environment to study the fundamental responses of humans and other organisms to gravity. These investigations will be performed in the pressurized cabin of the Space Shuttle Orbiter, or in a pressurized Spacelab module, or attached to an unpressurized Spacelab pallet. The Life Sciences also encompasses the research known as the Search for Extraterrestrial Life and Intelligence.

Life Sciences Missions

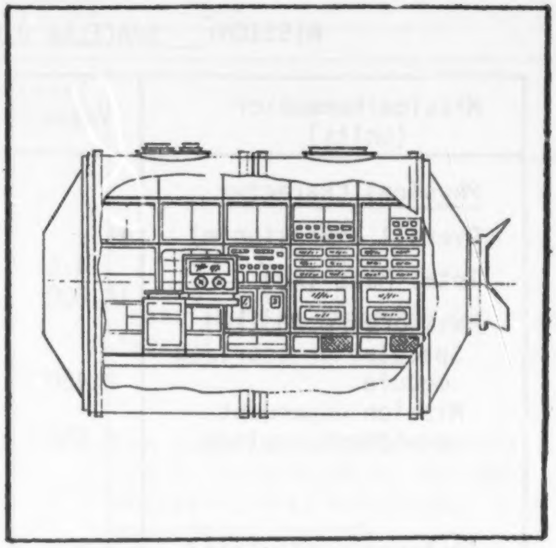
NO.

L-1 Spacelab Biological Experiments are to use the null gravity and altered environments of the space environment to further knowledge in medicine and biology for application to terrestrial needs, as well as to ensure human well-being and performance in space.

L-2 Space Sciences Platform is useful as a facility for long-duration flight experiments in the Life Sciences.

LIFE SCIENCES
MISSION: SPACELAB BIOLOGICAL EXPERIMENTS L-1

Status:	Planned
Lifetime:	7-30 days
Launch and Transfer Vehicles:	Shuttle/Spacelab
Operational Location:	300 km Earth orbit at 28.5 deg.
Total Mass at Operational Location:	Shuttle payload of up to 14,000 kg
Average Operational Power:	Less than 2.5 kw



OBJECTIVE: The Shuttle/Spacelab offers a unique capability to perform numerous experiments in all fields of life sciences; i.e., biomedicine, vertebrates, man/system integration, invertebrates, environment control, plants, cells, tissues, bacteria, and viruses. Broad objectives are to use the null gravity and altered environments (radiation, acceleration, light, magnetic fields, etc.) of the space environment to further knowledge in medicine and biology for application to terrestrial needs, as well as to ensure human well-being and performance in space.

DESCRIPTION: Initially, 7-day missions are scheduled with Spacelab dedicated to life sciences experiments. Eventually, flights as long as 30 days are envisioned. The carrier will generally consist of the pressurized Spacelab module with racks and payload support equipment; pallets may or may not be used. The Spacelab will be outfitted with selected common operational research equipment. For a given flight, 15 to 20 life sciences experiments will be carefully selected and developed that can be operated by one or two onboard payload specialists. These specialists may be supported by other onboard crewmembers and may receive real-time and off-line support from ground-based scientists and engineers via air-to-ground data, television, and voice communications links to the POCC and to remote monitoring areas. Several dedicated life sciences Spacelab missions are currently planned beginning in 1983. They are characterized by low-cost approaches, many flight opportunities, short experiment turnaround times, provisions for qualified investigators to fly with their experiments, and maximum use of existing or modified off-the-shelf hardware.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT: Not determined; to be chosen about two years prior to flight from about 80 investigations selected in 1979 for further definition; many investigations use common Life Sciences Laboratory Equipment (LSLE).

REFERENCES: Life Sciences Investigations on Space Shuttle/Spacelab Missions, Announcement of Opportunity No. OSS-1-78, 7 February 1978.
Life Sciences Laboratory Equipment (LSLE) Descriptions, Johnson Space Center, Report JSC-16254, 19 October 1979.

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LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACELAB BIOLOGICAL EXPERIMENTS L-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	15 x 4.5	3	Shuttle cargo volume.
Total Mass (kg)	14,000	3	Maximum Shuttle payload.
Mass breakdown (kg)			
Spacelab pressurized module	6,450	3	
Mission dependent equipment/payload	7,550	3	
Deployed/articulated items, size (m)	ND	3	An airlock is available for exposing objects up to 1 m diameter to the deep space environment.
Life			
Flight duration (days)	7-30	3,SOA	Initial flight is 7 days; later flights could be as long as 30 days and must include added life support consumables in the payload.
Number of spacecraft	1	3	
Orbit			
Periapse/apoapse altitudes (km)	300	3	Nominal Shuttle/Spacelab orbit.
Inclination (deg)	28.5	3	

LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACELAB BIOLOGICAL EXPERIMENTS L-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3,SOA	
Storage			
Capacity (bits)	4 x 10^{10}	3,SOA	Spacelab tape recorder for high rate data.
I/O rates (kbps)	64/16,000	3	
Spacecraft processors/ computers			
I/O rates (kbps)	3 x 10^5	3,SOA	Use Spacelab computer (Mitra 125 S, 16 bits/word) for data analysis, data handling, experiment control.
Memory size (bits)	64 K	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	Operations control center provides data to investigators.
Communications			
Minimum/maximum downlink rates (kbps)	64/50,000	3	Shuttle/Spacelab capabilities for digital data sent at K-band via TDRSS. Also can use video and voice channels.
Guidance & Attitude Control			
View direction	NA		Provided by Shuttle.
Position accuracy (km)	NA		Prefer quasi-inertial mode with low gravity environment.
Pointing accuracy (mrad)	NA		
Stability (mrad)	NA		

LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACELAB BIOLOGICAL EXPERIMENTS L-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	2.5	3,SOA	Use power produced by Shuttle's fuel cells; both 28 V DC and 115/200 V AC @ 400 Hz are available. Need additional energy kits if energy consumption of the payload exceeds 123 kWh.
Peak power consumed (We)	6.5	3	
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	NA		
Discharge rate (We)			
Discharge/recharge times (min)			
Thermal Control			
Component temperature (K)			
Refrigerators/ freezers	200-295	3,SOA	Several LSLE options available.
Incubator	295-320	3,SOA	A LSLE option.
Other equipment	~295	3	Cooled by convection or conduction; heat rejected by active Shuttle systems.
Component load (Wt)	ND	3	

LIFE SCIENCES
SENSOR/EXPERIMENT PARAMETERS

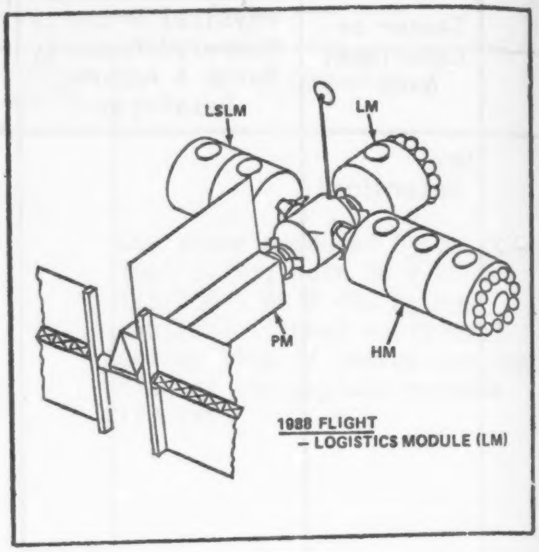
MISSION: SPACELAB BIOLOGICAL EXPERIMENTS L-1

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Not Determined			Life Sciences Experiments for Spacelab missions are to be chosen about 2 years before flight. About 80 investigations were selected in 1979 from those proposed in response to an Announcement of Opportunity. These investigations are to undergo further definition; many use the common Life Sciences Laboratory Equipment (LSLE). LSLE includes, centrifuges, blood and urine analysis, physiological transducers, oscilloscopes, recorders, microscopes, cameras, and facilities to support cells, tissues and small animals.

LIFE SCIENCES

MISSION: SPACE SCIENCES PLATFORM L-2

Status:	Planned
Lifetime:	10 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	400 km Earth orbit at 28.5 deg
Total Mass at Operational Location:	60,000 kg
Average Operational Power:	15 kw



OBJECTIVE: A Space Science Platform is useful as a facility for long-duration flight experiments in the Life Sciences. Broad objectives are to understand and mediate the effects of the space environment on humans and to increase our understanding of the effects of the unique space environment on biological processes. It is expected that all life sciences fields could benefit from human tended research with constraints on time, power, organism size, etc. that are more relaxed than Shuttle/Spacelab investigations.

DESCRIPTION: The configuration of the Space Science Platform used for life science investigations might include a Life Science Laboratory Module (LSLM), a Habitability Module (HM) and a Logistics Module (LM). These would be interconnected by a pressurized support module. Overall living and working space is about 200 m^3. A 25 kw Power Module provides basic engineering support for the platform. Several Shuttle flights would be needed to put the major components into orbit and to assemble them into a working platform. Life science investigations would be conducted by a crew of about six using the LSLM, which would be similar to a pressurized Spacelab module. The HM would permit 3 to 6 month intervals between Shuttle visits to exchange LM's and crew.

CRITICAL TECHNOLOGY NEEDS: Life support systems.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Varied; use a common set of research equipment; studies of requirements planned to begin in 1982.

REFERENCES: Science and Applications Study Report, MSFC, Program Development, 1 April 1979.

CONTACTS:
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LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE SCIENCES PLATFORM L-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension(m)	80 x 30 x 9	3	Major components assembled in orbit into platform.
Total Mass (kg)	60,000	3	
Mass breakdown (kg)			
Power Module	13,000		
Support Module	8,000		
Laboratory Module	12,000		
Habitability Module	16,000		
Logistics Module	8,000		
Propulsion	3,000		
Deployed/articulated items, size (m)			
Solar arrays (2)	40	3	
Pressurized volume (m^3)	200	3	
Life			
Flight duration (years)	10	3	
Number of spacecraft	1	3	
Service Interval (mo.)	3-6	3	For crew change and logistics resupply.
Orbit			
Periapse/apoapse altitudes (km)	400	3	Orbit altitude is a compromise considering atmospheric drag and dose from trapped radiation.
Inclination (deg)	28.5	3	

LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE SCIENCES PLATFORM L-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	ND	3,SOA	
Storage			
Capacity (bits)	ND	3,SOA	
I/O rates (kbps)	ND	3	
Spacecraft processors/ computers			
I/O rates (kbps)	ND	3,SOA	On-board computer to control experiments, collect and analyze data.
Memory size (bits)	ND	3	
Ground Processors/ computers			
Memory size (bits)	ND	3	
Communications			
Minimum/maximum downlink rates (kbps)	ND	3	Digital, video and voice channel via TDRSS using both S- and K-band services.
Guidance & Attitude Control			
View direction	ND	3	Gravity gradient stabilized to provide low gravity environment. Power Module provides active stabilization.
Position accuracy (km)	ND	3	
Pointing accuracy (mrad)	ND	3	
Stability (mrad)	ND	3	

LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE SCIENCES PLATFORM L-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	15,000	3	Solar cell arrays are part of Power Module.
Peak power consumed (We)	25,000	3	
Power breakdown (We)	ND	3	
Energy Storage			
Storage capacity (J)	ND	3	NiCd batteries in Power Module.
Discharge rate (We)	ND	3	
Discharge/recharge times (min)	30/60	3	
Thermal Control			
Component temperature (K)	ND	3	Active thermal control capability provided by Power Module.
Component load (Wt)	ND	3	

LIFE SCIENCES
MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPACE SCIENCES PLATFORM L-2

Mission Parameters (units)	Value	Confidence Level, Technology State	Comments
Chemical propulsion			
Total ΔV required (m/sec)	ND	3	Drag makeup.
Thrust level(N)			
Isp(sec)			
Propellant mass(kg)			
Inert mass(kg)			

LIFE SCIENCES
SENSOR/EXPERIMENT PARAMETERS

MISSION: SPACE SCIENCES PLATFORM L-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Not Determined			Purpose, method of experiment selection and operational philosophy might be the same as far as the Spacelab Biological Experiments.

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RESOURCE OBSERVATION

The Resource Observation program objectives include forecasting of agricultural production, exploration for mineral and energy resources, management of land use and water resources, and assessment of geodynamic hazards. Current efforts are concentrated in utilizing medium- to low-resolution instruments in a few spectral regions. Future emphasis will be on high-resolution (temporal, spatial, and spectral) studies in truly multispectral fashion, including magnetic, microwave, IR, visible, and stereo data.

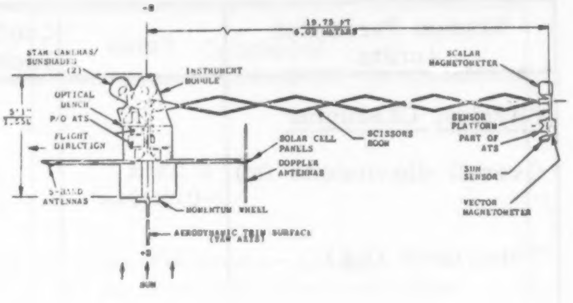
Resource Observation Missions

NO.	
R-1	Magsat is to map the magnetic field of the earth for the 1980 epoch and to obtain a global crustal anomaly distribution.
R-2	Landsat D is to provide data continuity of earth resources information for worldwide uses.
R-3	Crustal Dynamics Program will apply space methods and technology to advance the understanding of global earth dynamics.
R-4	Gravsat A will map the earth's gravity field at wavelengths of 100-1000 km and mean ocean surface topography for wavelengths of 100-3000 km.
R-5	Operational Earth Resources System provides a timely and reliable resource management system.
R-6	Advanced Thermal Mapping Applications Satellite.
R-7	Magnetic Field Survey B will increase the understanding of the solid earth and the processes leading to the decay of the earth's magnetic field.
R-8	Soil Moisture Research and Assessment Mission is a multispectral data acquisition facility capable of sending synoptic repetitive measurements of soil moisture.

RESOURCE OBSERVATION

MISSION: Magnetic Field Satellite (Magsat) R-1

Status:	Approved
Lifetime:	4-8 months reentry
Launch and Transfer Vehicles:	SCOUT "G" (launched 30 Oct 1979)
Operational Location:	350 km by 550 km earth orbit, 97° inclination
Total Mass at Operational Location:	174 kg
Average Operational Power:	125 W


-8
19.75 FT
6.02 METERS
STAR CAMERAS/ SUNSHADES (2)
INSTRUMENT MODULE
SCALAR MAGNETOMETER
OPTICAL BENCH
5'1"
1.55L
P/O ATS
FLIGHT DIRECTION
SOLAR CELL PANELS
SCISSORS BOOM
SENSOR PLATFORM
PART OF ATS
DOPPLER ANTENNAS
SUN SENSOR
S-BAND ANTENNAS
MOMENTUM WHEEL
VECTOR MAGNETOMETER
AERODYNAMIC TRIM SURFACE (YAW AXIS)
+8
SUN

OBJECTIVE:

Obtain quantitative description of earth's magnetic field, vector, and scalar. Particular interest in measuring and mapping magnetic anomalies.

DESCRIPTION: Magsat's mission is to map the magnetic field of the earth for the 1980 epoch and to obtain a global crustal anomaly distribution with a resolution of 350 km. Using Magsat data and airborne and ground survey data, the earth's main field will be modeled by a spherical harmonic expansion of degree and order fourteen. This will be the first time that global vector measurements will be made of the near earth field. Scalar data from the polar Orbiting Geophysical Observatory (OGO-2,4,6) satellites obtained in the late 1960s has been used to construct field models for that epoch and to develop crustal anomaly maps of coarse resolution.

Magsat is a cooperative effort between NASA and the United States Geological Survey. The USGS plans to use the Magsat observations and models to update regional and global magnetic charts and maps, which are published by the USGS.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Scalar magnetometer, vector magnetometer.

REFERENCES: (1) Design Specification for the Magsat Spacecraft, APL/JHU Doc. No. 7249-9007, Revision B, March 1979; (2) Magsat Magnetic Field Satellite Resource Observation Program, NASA (undated); (3) Mission Operation Report, Magnetic Field Satellite, Magsat (AEM-C), OSTA Report No. E-662-79-01, 17 September 1979.

CONTACTS:

J. Murphy, NASA Headquarters, Code ERG-2, 755-3848

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Satellite (Magsat) R-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	1.55 x ~0.5 dia	1	
Total mass (kg)	174	1	
Deployed items, size (m)			
1. Boom for instruments	6.02	1	Also aerodynamic trim boom (8 ± 3m)
2.			
Life			
Flight duration (days)	4-8 mos	1	Aerodynamic drags leads to ultimate atmosphere reentry
Number of spacecraft	1	1	
Orbit			
Altitude (km)	350 perigee 550 apogee	1 1	Sun synchronization
Inclination (deg)	96.9	1	

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Satellite (Magsat) R-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	1.69×10^8	1, SOA	
Storage capacity (bits)	9×10^7	1, SOA	2 tape recorders (single track), values are for each recorder
I/O rates (bps)	2×10^3/ 3.2×10^5	1, SOA	
Spacecraft processors/ computers			Housekeeping, command processing
I/O rates (bps)			
Memory size (bits)	65,000	1, SOA	
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)	70-m a track 40-m c track 40-m vertical	1, SOA	Using a Doppler beacon system
Pointing accuracy (mrad)	±0.06 rms	1, SOA	Jitter accuracy = 0.07 rms
Stability (mrad)			
Type of control system			Magnetometer, star cameras, coarse sun sensor, precision sun sensor, IR horizon scanner, rate gyro

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Satellite (Magsat) R-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power		1	Solar cell array/battery
Average power consumed (kWe)	120-160W	1	
Peak power consumed (kWe)			
Power breakdown (We)			
Tape recorders	up to 25 W	1	
Energy Storage			
Storage type		1	12 8 A-hr NiCd batteries. Nominal voltage: 16.7 V
Energy/cycle (J)			
Communications		1	Direct to NASA ground stations
Link, type of data and rate (Mbps)	320 kbps	1, SOA	

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Satellite (Magsat) R-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			Louvers and radiators for excess power
Component temperature (K)			
1.			
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion	NA		Launched directly into final orbit, then allowed to decay and reenter the atmosphere.
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

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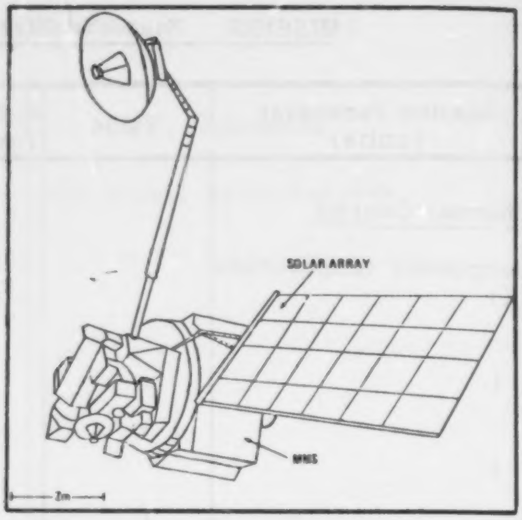
RESOURCE OBSERVATION

MISSION: Landsat D R-2

Status:	Approved
Lifetime:	3 yr, each spacecraft before retrieval/refurbishment
Launch and Transfer Vehicles:	Delta 3920 eventually Shuttle/IUS
Operational Location:	Polar, sun synchronous earth orbit, 705 km alt
Total Mass at Operational Location:	1597 kg
Average Operational Power:	750 W



OBJECTIVE: To provide data continuity of earth resources information for worldwide users. The Multispectral Scanner will provide data in the same format as is currently available from previous Landsats. The capability of the Thematic Mapper to provide improved earth resources management information due to its greater spectral and spatial resolution will be assessed.

DESCRIPTION: The Landsat D project will involve orbiting an observatory designed to be compatible with the Shuttle retrieval and replacement capabilities, and which will incorporate both a Thematic Mapper and a Multispectral Scanner (MSS). The spacecraft and attendant sensors will send data through the Tracking and Data Relay Satellite System (TDRSS) to produce an average of 50 TM and 200 MSS scenes per day over selected regions of the earth. The Landsat D program as presently defined includes a second flight segment which will be available for launch, if necessary, to achieve the overall program objectives.

The primary applications areas which are expected to benefit from Landsat D data are crop acreage and yield assessment, water resources management, mineral and petroleum exploration, and land-use planning and monitoring.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Thematic mapper, Multispectral scanner.

REFERENCES:

Execution Phase Project Plan for Landsat D, GSFC, April 1978

CONTACTS:

H. Mannheimer, NASA HQ, Code ERC-2, 755-1201

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Landsat D R-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			Moving parts (TM & MSS oscillating mirrors, solar panels, TDRSS antenna) degrade ultimate mapping accuracy
Total mass (kg)	1597	1	
MSS spacecraft	659	1	
Propulsion module	150	1	
Flight adapter	57	1	
Instruments	351	1	
Other	380	1	Solar array, wide band data module, TDRSS antenna, thermal control
Deployed items, size (m)			
1. Solar array (FRUSA)		1	
2. TDRSS antenna on boom		1	
Life			
Flight duration (days)	3 years	1	
Number of spacecraft	2	1	One on-ground backup, one in orbit
Orbit		1	Sun synchronization
Altitude (km)	699-717	1	705.3 nominal
Inclination (deg)	98.2	1	
Ground trace repeat	1	1, SOA	Desire ± 150m for repeat of ground trace Local sun angle of 9:30 am at descending node

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Landsat-D R-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	4×10^{11}	1, SOA	One spacecraft, excluding transmission to foreign ground stations
Storage capacity (bits)			Supplied by MMS bus
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers		1, SOA	Data corrections, generation of archival tapes and film
Speed (Ops)	13.5 M		Nominal, (words = operations)
Memory size (bits)			
Time from acquisition to archival product (hours)		1, EV	
Guidance & Attitude Control		1	GPS
Position accuracy (km)	1	1, SOA	Nadir looking
Pointing accuracy (mrad)			DRIRU for MMS
Stability (mrad)			
Type of control system			

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Landsat-D R-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power		1	Photovoltaic
Average power consumed (kWe)	0.75	1, SOA	
Peak power consumed (kWe)			
Power breakdown (We)			
Thematic mapper	320	1	
Thermal control	40	1	
Multispectral scanner	120	1	
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications		1, EV	Relayed through TDRSS to White Sands, NM, then via Domsat to GSFC, and then to EDC via Domsat. Also direct to foreign ground stations
Link, type of data and rate (Mbps)	Digital, 100 Mbps	1, EV	TDRSS single access mode

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Landsat-D R-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control		1, EV	Passive radiation coolers for IR detectors in Thematic Mapper (2 stage)
Component temperature (K)			
1. Radiators with louvers	288-303	1, SOA	Dump electronics heat to space
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	NA		Spacecraft injected into final orbit by Delta 3920 launch vehicle and or shuttle. Note: A propulsion module is used to achieve shuttle retrievability.
Thrust level (N)			
I_{sp} of stages (sec)			

RESOURCE OBSERVATION

MISSION: Crustal Dynamics Program R-3

Status: Approved

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE:

Apply space methods and technology to advance scientific understanding of global earth dynamics, and to support the US program in earthquake hazard reduction.

DESCRIPTION:

The Crustal Dynamics Program is a joint effort among NASA, USGS, NSF, DoD, National Geodetic Survey, and foreign agencies to study plate motion, plate deformation and regional deformations, polar motion and earth rotation, and magnetic and gravitational fields. Data gathered by a large variety of ground- and space-based systems will be utilized. These include Lageos, Magsat A and B, laser measurements, VLBI station, GPS, and Shuttle-based experiments.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

Applications of Space Technology to Crustal Dynamics and Earthquake Research, NASA Technical Paper 1464, NASA Headquarters, August 1979

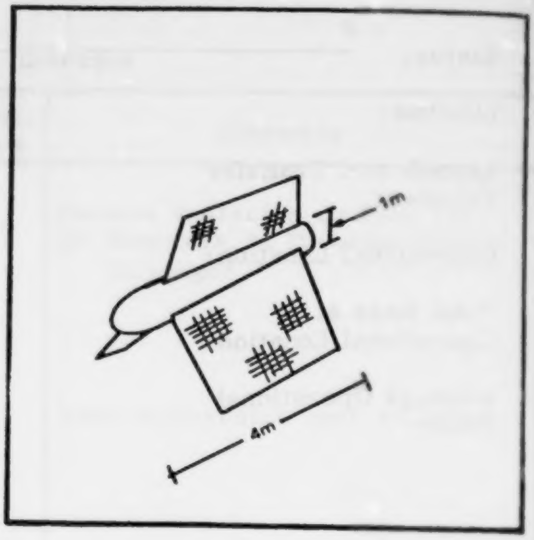
CONTACTS:

T. Fichetti, NASA HQ, Code ERG-2, 755-3848

RESOURCE OBSERVATION

MISSION: Gravsat A R-4

Status:	Planned
Lifetime:	9 months
Launch and Transfer Vehicles:	Shuttle
Operational Location:	Near polar earth, 170-km altitude
Total Mass at Operational Location:	4000 kg each satellite
Average Operational Power:	150 W



OBJECTIVE:

Map the earth's gravity field at wavelengths of 100-1000 km with an accuracy of ±3 mgal and mean ocean surface topography to ±10 cm for wavelengths from 100 km to 3000 km for solid earth studies, resource exploration, and studies of ocean processes.

DESCRIPTION:

As currently envisioned, the Gravsat mission consists of two satellites, in the same low earth orbit, separated by up to a thousand kilometers. Highly accurate tracking using TDRSS, GPS, satellites-to-satellite ranging, and DMA Doppler network, will be used to derive gravity field effects at various wavelengths. Analysis of variations in the observed range rate between the satellites will yield information about currently unknown components in the gravity field. Spacing of the two low-altitude satellites will be varied to filter out specific gravity wavelengths. Nongravitational forces will be compensated to maintain a purely gravitational orbit by a surface force compensation system.

It is expected that a dedicated gravitational satellite mission will provide useful new information both on the mechanical properties of the plates which make up the earth's surface and on the deep processes occurring beneath the plates, such as those associated with the driving mechanism of plate tectonics as well as aiding in the study of ocean circulation by providing the static surface, i.e., the ocean geoid.

CRITICAL TECHNOLOGY NEEDS:

Drag compensation techniques to permit very low orbital altitudes to improve spatial resolution.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Range rate measuring devices, drag free inertial system plus 100 GHz Doppler tracking.

REFERENCES:

Applications of a Dedicated Gravitational Satellite Mission, National Academy of Sciences, Washington, D.C., 1979
Gravsat Study Plan, Goddard Space Flight Center, in press.

CONTACTS:

T. Fichetti or J. Murphy, NASA HQ, Code ERG-2, 755-3848.

S. Willis or D. Smith, GSFC.

RESOURCE OBSERVATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Gravsat A R-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	4-m long x 1-m diameter		
Total mass (kg)	4000	3	
1. Propellants	2000		
2. Engines, power, guidance, tankage	500		
Deployed items, size (m)	N/A		
1.			
2.			
Propellant pressure (pascals)	20.7×10^6		3000 PSIA
Life			
Flight duration	9 months	2	
Number of spacecraft	2	3	
Orbit			
Altitude (km)	250	3	Both spacecraft are in the same orbit but separated by about 2°.
Inclination (deg)	polar	3	

RESOURCE OBSERVATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Gravsat A R-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	150 W		
Peak power consumed (kWe)	150 W		
Power breakdown (We)			
Energy Storage			
Storage type	20 amp/hr each 20 Nms		NiCd batteries (16) 3500 cycles, 30 min recharge Momentum wheels (2)
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			TDRSS for telemetry DMA Doppler for tracking

RESOURCE OBSERVATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Gravsat A R-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	10^8		
Storage capacity (bits)	10^8		Tape recorders (2)
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)	1 m on S/C		Important observable is separation rate to an accuracy of 1 μ/s
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system	Freon thrusters		Thrust level: 0.1 N I_{sp}: 40 sec Continuous thrusting

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

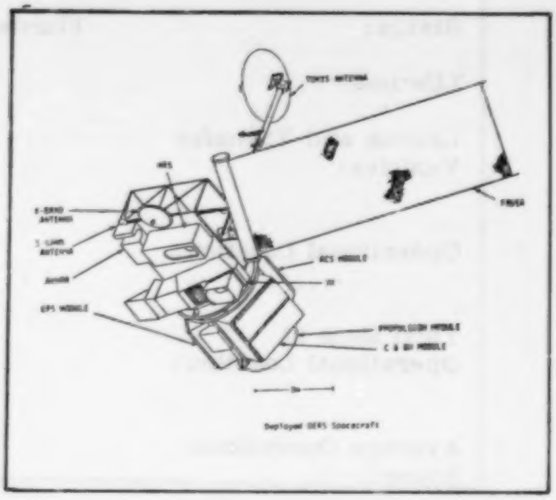
MISSION: Gravsat A R-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			Heat pipes
Component temperature (K)			
1.			
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	NA		
Thrust level (N)			
I_{sp} of stages (sec)			

RESOURCE OBSERVATION

MISSION: Operational Earth Resources System (OERS) R-5

Status:	Planned
Lifetime:	3 year design life for single spacecraft
Launch and Transfer Vehicles:	Shuttle and Upper Stage (TBD)
Operational Location:	
Total Mass at Operational Location:	1650 kg
Average Operational Power:	750 W



Deployed OERS Spacecraft

OBJECTIVE: Provide timely and reliable resource management information beyond Landsat on an operational basis in support of multidisciplinary earth resources requirements.

DESCRIPTION: The system concepts has been under intensive review with NOAA. Initial definition may be complete by summer 1980.

CRITICAL TECHNOLOGY NEEDS: Inexpensive redundancy for 3-5 years. 150 Mbps on-board data storage. Detector arrays for 1-2.5 μm, and 10.5-12.5 μm spectral region.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Under review.

REFERENCES:

SDP/SIM NASA Global Services System, Phase 2 - Operational Earth Resources System (OERS), Final Report, General Electric Company, October 1978.

CONTACTS:

William Piotrowski, NASA HQ, Code ER-2, 755-6038.

RESOURCE OBSERVATION

MISSION: Advanced Thermal Mapping Applications Satellite R-6

Status: Planned

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE: A specific objective has not been enunciated. However, the thermal spectral region has the potential to provide very important remote sensing information, especially through the use of narrow spectral bands.

DESCRIPTION:

CRITICAL TECHNOLOGY NEEDS: High Sensitivity Photodetectors to permit moderate to high Resolution Radiometry (100 m to 150 m IFOVs) in narrow (40 nm -60 nm) spectral bands in the 8 to 15 µm spectral region. Factors of 2 to 4 improvement in NEP may be required beyond that provided by the SOA focal plane of the Thematic Mapper.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

CONTACTS:

William Piotrowski, NASA HQ, ER-2, 202/755-6038

RESOURCE OBSERVATION

MISSION: Magnetic Field Survey B R-7

Status: Planned

Lifetime: 5 years

Launch and Transfer Vehicles: Shuttle and SSUS-A

Operational Location: 300-km altitude, 97° inclination orbit

Total Mass at Operational Location: 800 kg

Average Operational Power:

OBJECTIVE:

Increase understanding of the solid earth and the processes leading to the decay of the earth's magnetic field, and secular variations. Provide information for the updating of magnetic field charts and maps by the USGS. Provide greater resolution in mapping anomalies for resource assessment purposes.

DESCRIPTION:

Currently the primary option being considered for the Magnetic Field Survey B mission is a small spacecraft similar to Magsat with scalar and vector field magnetometers flown in a polar low orbit. The satellite will be retrievable and serviced by the Shuttle to assure operations for at least 5 years. Each year a complete survey of the earth's magnetic field will be obtained.

Two other options also being considered for this mission are: (1) a tethered magnetometer; several 6/7 day missions would be required to gather the minimum data required; (2) add magnetometer(s), on a trailing boom, to one of the two proposed low-orbit Gravsat spacecraft.

CRITICAL TECHNOLOGY NEEDS:

Precision attitude transfer system (20 arc sec)

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Scalar magnetometer, vector magnetometer.

REFERENCES:

CONTACTS:

J. Murphy, NASA HQ, Code ERG-2, 755-3848

T. Fichetti, NASA HQ, ERG-2

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Survey B R-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total mass (kg)			
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)			
Number of spacecraft			
Orbit			
Altitude (km)			As low as possible
Inclination (deg)			Nearly polar
Synchronization			Probably sun synchronous

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Magnetic Field Survey B R-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			Low
Storage capacity (bits)	10^8		Tape recorders (2)
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

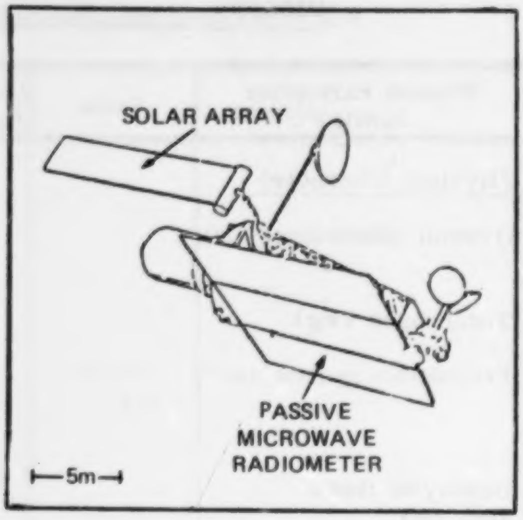
MISSION: Magnetic Field Survey B R-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)			
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			

RESOURCE OBSERVATION

MISSION: Soil Moisture Research and Assessment Mission R-8

Status:	Candidate
Lifetime:	2-3 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	465 km
Total Mass at Operational Location:	
Average Operational Power:	1.2 kW



OBJECTIVE:

A multispectral space data acquisition capability capable of providing synoptic repetitive measurements of soil moisture in support of agriculture, water resources, and climate information needs.

DESCRIPTION:

CRITICAL TECHNOLOGY NEEDS:

Large passive microwave antennas

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

CONTACTS:

Larry King, GSFC - Sensors
M. Calabrese, NASA HQ, Code ERL-2

RESOURCE OBSERVATION
MISSION TECHNOLOGY REQUIREMENTS

R-8

MISSION: Soil Moisture Research and Assessment Mission

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total mass (kg)			
Propulsion system (wet)	176-242 618	1, SOA	Option I Option II
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)			
Number of spacecraft			
Orbit			
Altitude (km)	645		
Inclination (deg)			Sun synchronous
Equatorial crossing time	2 am 2 pm		Spacecraft local time

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Soil Moisture Research and Assessment Mission R-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Time accuracy	1×10^{-6}		
Pointing accuracy (mrad)	±0.175	1, SOA	
Stability (mrad)	±10	1, SOA	Reaction wheels
Time stability	2×10^{-8}		Daily
Type of control system			Standard MMS system

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Soil Moisture Research and Assessment Mission R-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	0.25-1.2	1, SOA	MMS capability
Peak power consumed (kWe)	3.0 for 10 min	1, SOA	MMS capability
Power breakdown (We)			
Energy Storage			
Storage type	NiCd batteries		3 maximum, either 20 A-hr or 50 A-hr each (MMS)
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			

RESOURCE OBSERVATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Soil Moisture Research and Assessment Mission R-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	60 415		Option I (MMS) Option II (MMS)
Thrust level (N)	11		
I_{sp} of stages (sec)	220		

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Resource Observation Instruments

RI-1	Vector and Scaler Magnetometers
RI-2	Multispectral Scanner
RI-3	Thematic Mapper
RI-4	Shuttle Multispectral Infrared Radiometer
RI-5	Large Format Camera
RI-6	Shuttle Imaging Radar-A (SIR-A)
RI-7	Multispectral Linear Array
RI-8	Range Rate Measuring Devices
RI-9	Time and Frequency Transfer Experiment
RI-10	Gravity Gradiometer
RI-11	Multispectral Mid-IR Imager
RI-12	Passive Microwave Radiometer
RI-13	Active Microwave Sensor
RI-14	Thermal IR Sensor
RI-15	Visible IR Sensor
RI-16	Earth Resources Synthetic Aperture Radar

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INSTRUMENT: Vector and Scalar Magnetometers RI-1

STATUS: Approved

CARRIER: Magnetic Field Satellite (MAGSAT)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Obtain quantitative description of earth's magnetic field, vector and scalar. Particular interest in measuring and mapping magnetic anamolies.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Vector Magnetometer: Geomagnetic field -- ±64,000γ per component;
accuracy -- 3γ rms
Scalar magnetometer: accuracy ±3γ
Operating on Magsat launched 30 October 1979.

ASSOCIATED RANGES AND/OR RESOLUTION:

At least 2 observations per second, vector and scalar.

COMMENTS:

Vector Magnetometer: Direct Measure
Scalar Magnetometer: Uses energy levels in Cs 133 to measure field strengths.

SOURCE/CONTACT:

J. Murphy, NASA HQ, Code ERG-2, 755-3848

INSTRUMENT: Multispectral Scanner RI-2

STATUS: Approved

CARRIER: Landsat D
Landsat D^1

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): _

Power Requirement (We): 120

Mass (kg):

Data Rate: 15 Mbps

PRINCIPAL PURPOSE AND FEATURES:

This instrument provides earth radiance data continuity with previous Landsats. It is essentially identical to the MSS flown on Landsats 1, 2, and 3.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Reflected earth radiance.

ASSOCIATED RANGES AND/OR RESOLUTION:

82.6 m pixel, 185 km swath width
16 day repeat over life of mission
4 bands: 0.5-0.6, 0.6-0.7, 0.7-0.8, 0.8-1.1 microns
Electromechanical scan, 6 detectors/band

COMMENTS:

SOURCE/CONTACT:

H. Mannheimer, NASA HQ, Code ERC-2, 755-1201

INSTRUMENT: Thematic Mapper RI-3

STATUS: Approved

CARRIER: Landsat D

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m) : 1.1 x 0.7 x 2.0

Power Requirement (We): 320

Mass (kg): 239

Data Rate : 85 Mbps

PRINCIPAL PURPOSE AND FEATURES:

Provide global resources information, primarily for agricultural and hydrological uses, geologic and land use assessments.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: Reflected/emitted earth radiance

7 bands:	Microns	Sensitivity
	0.45-0.52	0.8%
	0.52-0.60	0.5%
	0.63-0.69	0.5%
	0.76-0.90	0.5%
	1.55-1.75	1.0%
	2.08-2.35	2.4%
	10.4-12.5	0.5 K

30 m pixel (except 120 m for thermal band), 180 km swath width (1, SOA)

16 day repeat over life of mission (1, SOA)

ASSOCIATED RANGES AND/OR RESOLUTION:

40 cm diam. Ritchie-Chretien telescope (1,SOA)
Photodiode detectors:
  Si: 4 mil
  InSb: 2 mil
  HsCdTe(PC): 8 mil

Electromechanical scan,
16 detectors/band
85 Mbps data rate
256 levels quantization
Interband registration of 0.1 IFOV
Long-term scan stability of 0.5 IFOV

COMMENTS:

SOURCE/CONTACT:

H. Mannheimer, HASA HQ, Code ERC-2, 755-1201

INSTRUMENT: Shuttle Multispectral Infrared Radiometer RI-4

STATUS: Approved

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.94 × 0.559 × 1.226

Power Requirement (We): 120 (peak)

Mass (kg): 86

Data Rate (kbps): 36

PRINCIPAL PURPOSE AND FEATURES:

To obtain earth surface radiance measurements in the 0.5-2.35 μm spectral region from orbit. To be used for design parameters for future imaging systems directed towards geologic mapping, including determination of atmospheric and vegetation effects.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Spectral range 0.5-2.35 μm.

ASSOCIATED RANGES AND/OR RESOLUTION:

Two detectors, operating temperature 193 K aligned along track. Telescope, all reflective, f/7.6, 137.1 cm focal length.

COMMENTS:

SOURCE/CONTACT:

B. B. Schardt, ERS-2.

INSTRUMENT: Large Format Camera (LFC) RI-5

STATUS: Approved

CARRIER: Shuttle payload
Orbiter Camera Payload
System (OCPS)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 2.91 m^3

Mass (kg): 511.5

Power Requirement (We): 262 (nominal)
700 (peak)

Data Rate (kbps): 0.405

PRINCIPAL PURPOSE AND FEATURES:

To photograph the earth's land and ocean surfaces (and meteorological phenomena) for geological exploration, cartography, and renewable resource analysis.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

The LFC will be carried on a pallet or Standard Test Rack as a component of the OCPS and will require STS power, command and telemetry services, and some crew time for operation. It is comprised of the LFC, mount structure, environmental enclosure, pneumatic supply, and electronics assembly. Thermal control is passive cooling and active heating. LFC lens focal is 30.5 cm. Image size on film is 45.7 cm (along track) by 22.9 cm (across track). Spectral range is 400-920 nm depending on film used. Maximum film capacity is 2400 frames.

ASSOCIATED RANGES AND/OR RESOLUTION:

Orbit characteristics:	Desired	Minimum	Maximum
Altitude, km	222	185	325
Inclination, deg	57	30	95.5

Look angle from NADIR: 0 degrees
Sun angle elevation: 10 to 90 degrees
Pointing, stability, and control:
Pointing accuracy: ±35 mrad Drift rate: 0.485 mrad/s
Stability: 1.75 mrad

COMMENTS:

SOURCE/CONTACT:

D. P. Rogers, ERS-2.
STS Payload Planning Data, Volume II, P179-MSFC-2327, April 1979

INSTRUMENT: Shuttle Imaging Radar-A (SIR-A) RI-6

STATUS: Approved **CARRIER:** Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 2.73 m^3

Power Requirement (We): 800 Pallet } Peak
200 Module }

Mass (kg): 480

Data Rate (kbps): 120,000 (Optical recorder)

PRINCIPAL PURPOSE AND FEATURES:

Extend the coverage of earth resources remote sensors to a new spectral region (i.e., microwave region). Study the complementary aspect to Landsat. Application to different disciplines such as geology, oceanography.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Charles Elachi, JPL, (213) 354-5673

INSTRUMENT: Multispectral Linear Array (MLA) RI-7

STATUS: Planned

CARRIER: ND

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The MLA is in an early stage of definition: tentatively, it is a pushbroom scanner. The antecedent Multispectral Resource Sampler (MRS) concept is described here as an indication of the potential properties of the MLA. The pointable MRS enables disaster assessment and crop inventory information to be obtained more often than every 16 days. In addition, the high spatial and spectral resolutions provide details not otherwise available. It uses a 4 × 2000 pushbroom (1, EV), whose pointing angle was varied.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Reflected earth radiance.

ASSOCIATED RANGES AND/OR RESOLUTION: (MRS)

20 bands available, with 20-50 nm spectral resolution, from 0.36-0.95 μm (2, EV); ±40° across track and ±55° along track pointing (2, EV); 2-3 day repeat over life of mission (2, EV); high-resolution mode: 15 m pixel, 15 km swath width, any 2 bands (2, EV); low-resolution mode: 30 m pixel, 30 km swath width, any 4 bands (2, EV).

COMMENTS:

SOURCE/CONTACT:

William Piotrowski, NASA HQ, Code ER-2, 755-6038

RESOURCE OBSERVATION

INSTRUMENT: Range Rate Measuring Devices RI-8

STATUS: Planned **CARRIER**: Gravsat A

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): **Power Requirement (We)**:

Mass (kg): **Data Rate (kbps)**:

PRINCIPAL PURPOSE AND FEATURES:

The objective is to measure the changes in range rate between the two proof masses in each spacecraft, which fly in a "gravitational orbit" due to the "drag free" systems, with an accuracy of 1 micron per second averaging over about 10 seconds. Time changes in range rate are then interpreted in terms of accelerations due to unknown components in the gravity field.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Satellite - satellite separation changes to an accuracy of 10^{-5}-10^{-6} m/sec.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

T. Fichetti or J. Murphy, NASA HQ, Code ERG-2, 755-3848

S. Willis or D. Smith, GSFC

RESOURCE OBSERVATION

INSTRUMENT: Time and Frequency Transfer Experiment RI-9

STATUS: Planned **CARRIER:** Shuttle Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.91 × 1.22 × 1.22 **Power Requirement (We):** 200

Mass (kg): 90.7 **Data Rate (kbps):** TBD

PRINCIPAL PURPOSE AND FEATURES:

To demonstrate the transfer of time from space to ground with an accuracy of 10^{-14} Requires hydrogen imager clock on shuttle, ground laser systems, and three way Doppler microwave (one up; two down).

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Program is in a very preliminary stage.

SOURCE/CONTACT:

Dr. Rudy Decher, MSFC, (205) 453-5130

RESOURCE OBSERVATION

INSTRUMENT: Gravity Gradiometer RI-10

STATUS: Planned **CARRIER:** Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): **Power Requirement (We):** 1

Mass (kg): 6.8-9.1 **Data Rate (kbps):**

PRINCIPAL PURPOSE AND FEATURES:

A means for obtaining an improved global model of the earth's gravity field.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

M. Page, MSFC, (205) 433-3425

INSTRUMENT: Multispectral Mid-IR Imager (MMIRI) RI-11

STATUS: Planned **CARRIER:**

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.5 × 1.0 (diam) **Power Requirement (We):** 300

Mass (kg): 900 **Data Rate (kbps):** 15-30

PRINCIPAL PURPOSE AND FEATURES:

To make geological observations of the earth by means of thermal infrared images in 6 spectral bands between 8-12μ. Would like 3 or more years observation, but not necessarily continuously.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Measures thermal images of earth emission using 1000 element array detector.

ASSOCIATED RANGES AND/OR RESOLUTION:

Ground resolution 100 m, swath width 100 km.

COMMENTS:

Launch ready date late 80's. Schedule is dependent on mid-IR detector technology.

SOURCE/CONTACT:

Alexander Goetz, JPL, (213)354-3254

INSTRUMENT: Passive Microwave Radiometer RI-12

STATUS: Planned

CARRIER: Soil Moisture Research and Assessment

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

10 × 10 m planar phased array.
Soil moisture inventory instrument.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Surface brightness temperature.

ASSOCIATED RANGES AND/OR RESOLUTION:

1.400-1.427 GHz BW; 12 km IFOV; 870 km swath width.

COMMENTS:

SOURCE/CONTACT:

Larry King, GSFC - Sensors
M. Calabrese, NASA HQ, Code ERL-2

INSTRUMENT: Active Microwave Sensor RI-13

STATUS: Planned

CARRIER: Soil Moisture Research and Assessment

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.5 × 10

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Soil moisture sampling.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Surface backscatter coefficient.

ASSOCIATED RANGES AND/OR RESOLUTION:

4.50-5.00 GHz BW; 100 m IFOV; 290 km swath width.

COMMENTS:

SOURCE/CONTACT:
Larry King, GFST - Sensors
M. Calabrese, NASA HQ, Code ERC-2

INSTRUMENT: Thermal IR Sensor RI-14

STATUS: Planned

CARRIER: Soil Moisture Research and Assessment

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Surface brightness temperature measurements

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Surface temperature

ASSOCIATED RANGES AND/OR RESOLUTION:

10.5-12.5 μm BW; 0.5 K NEΔT; 500 m IFOV; 870 km swath width

COMMENTS:

SOURCE/CONTACT:

Larry King, GSFC - Sensors
M. Calabrese, NASA HQ, Code ERL-2

RESOURCE OBSERVATION

INSTRUMENT: Visible IR Sensor RI-15

STATUS: Planned

CARRIER: Soil Moisture Research and Assessment

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Measure surface orientation.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Surface radiance.

ASSOCIATED RANGES AND/OR RESOLUTION:

0.4-1.0 μm BW; 500 m IFOV; 870 km swath width.

COMMENTS:

Provide reference for microwave and infrared data intepretation.

SOURCE/CONTACT:

Larry King, GSFC - Sensors
M. Calabrese, NASA HQ, Code ERL-2

INSTRUMENT: Earth Resources Synthetic Aperture Radar RI-16

STATUS: Planned **CARRIER:** Space Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To obtain day/night, all weather earth resources information. Dual linearly polarized L- and X-, and/or C band SAR.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Reflected radar signal.

ASSOCIATED RANGES AND/OR RESOLUTION:

Swath width: 50 km for all look angles.
Ground resolution: 50 m (15°), 25 m (47°), 20 m (60°).

COMMENTS:

These parameters may change significantly based on the deliberations of the ERSAR Steering Group which is currently reevaluating system requirements.

SOURCE/CONTACT:

B. Schardt, NASA HQ, Code ERS-2, 755-3752

GLOBAL ENVIRONMENT

The Global Environment program objectives include monitoring and forecasting of global weather and local severe storms, assessment and forecasting of climate, monitoring and forecasting of ocean conditions, and assessment of air and water quality. The future emphasis will be on multi-instrument systems to measure a variety of phenomena simultaneously, and on geosynchronous observations.

Global Environment Missions

NO.

E-1 Stratospheric Aerosol and Gas Experiment is to determine the spatial distribution of stratospheric aerosols and ozone on a global basis.

E-2 The Geostationary Orbiting Environmental Satellite provides atmospheric sounding, continuous observations of earth's surface and cloud cover, daytime visible observations, daytime and nighttime infrared observations and space environment monitoring.

E-3 Solar Mesosphere Explorer provides a comprehensive study of atmospheric ozone.

E-4 Earth Radiation Budget Satellite will develop a global system for measurement of the components of the earth's radiation budget.

E-5 NOAA A-G satellites provide operational weather data for NOAA and support the Global Atmospheric Research Program and needs of NOESS (National Operational Environmental Satellite System).

E-6 National Oceanic Satellite System (NOSS) will provide a limited operational demonstration of global sea surface observation capability for ocean processes, ice dynamics, and coastal processes.

E-7 Upper Atmospheric Research Satellite (UARS) will study the radiation, chemistry, and dynamics of the upper atmosphere.

E-8 NOSS Research Program will permit the study and characterization of the polar regions by flying on NOSS instruments identified for the ICEX satellite, which is no long being considered.

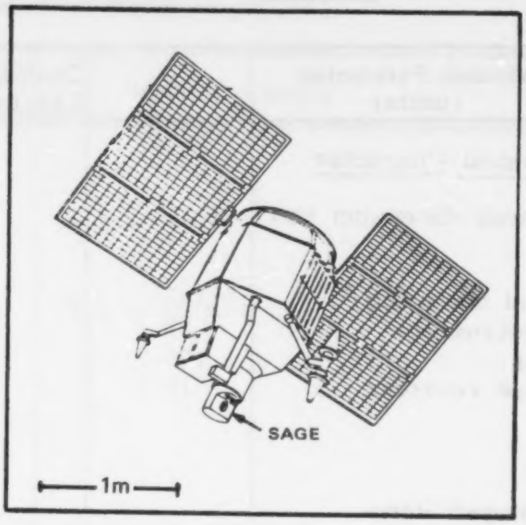
E-9 Ocean Circulation Mission - Topography Experiment (TOPEX) will map the surface topography of the ocean.

E-10 Operational Meteorology Satellite(s) is envisioned as a follow-on to the NOAA A-G and GOES meteorological satellites.

E-11 Ocean Research will deploy a synthetic aperture radar to study oceanic and ice features.

MISSION: Stratospheric Aerosol and Gas Experiment (SAGE) E-1

Status:	Approved
Lifetime:	1 year
Launch and Transfer Vehicles:	Scout
Operational Location:	600 km
Total Mass at Operational Location:	147 kg (AEM-B)
Average Operational Power:	50 W



OBJECTIVE: To determine the spatial distribution of stratospheric aerosols and ozone on a global scale. In particular: (a) to develop a viable satellite-based remote sensing technique for measuring stratospheric aerosols and ozone; (b) to map vertical extinction profiles of stratospheric aerosols and ozone globally from 78°S to 78°N latitude; (c) to investigate aerosol optical properties using flight experiment and ground truth data.

DESCRIPTION: SAGE's mission is to map in the stratosphere vertical profiles of ozone, aerosol, nitrogen dioxide, and molecular extinction around the globe. The ozone data are expected to extend from about 8-48 km (5-30 mi); aerosol data from the cloud tops to 35 km (22 mi) (plus occasional strong layers in the mesosphere); nitrogen dioxide data from 20-40 km (15.5-25 mi); and molecular extinction from about 15-40 km (9-25 mi).

SAGE will lock on to the sun as the spacecraft experiences a sunrise or sunset and measure the sun's brightness at four colors or wavelengths. This information is interpreted in terms of vertical profiles of the atmospheric constituent that attenuated or dimmed the sunlight. Thirty profiles per day are obtained in this manner spread over latitude and longitude. Over a year, 10,000 profiles are measured from 78°S to 78°N latitude.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Four-channel spectral radiometer (SAGE)

REFERENCES: (1) Prelaunch Mission Operation Report, E-659-79-01, 24 January 1979; (2) Execution Phase Project Plan for Applications Explorer Mission-B Stratospheric Aerosol and Gas Experiment (SAGE), Rev. 1, GSFC, November 1978; (3) Stratospheric Aerosol and Gas Experiment of the Applications Explorer Missions Program, GSFC (general information handout)

CONTACTS:

D. Diller, EB-8

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Stratospheric Aerosol and Gas Experiment (SAGE) E-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)	1.45		Overall height, includes antenna
Total mass (kg)	147		
Instruments	27.7		
Bus	105.2		
Tape recorder	14.1		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	365		
Number of spacecraft			
Orbit			
Altitude (km)	600		Circular
Inclination (deg)	56		

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Stratospheric Aerosol and Gas Experiment (SAGE) E-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	4.7×10^8		Estimated
Storage capacity (bits)	4.5×10^8		Tape recorders (2)
I/O rates (bps)	5440/328K		
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			Sun sensors, horizon sensors and magnetometers
Position accuracy (km)			
Pointing accuracy (mrad)	±0.22		Sun sensor azimuth tolerance
Stability (mrad)			
Type of control system			

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Stratospheric Aerosol and Gas Experiment (SAGE) E-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	29-82 We		
Peak power consumed (kWe)	82 We		Operation and data dump
Power breakdown (We)			
Bus module	27.5-53.7		
Instruments/module	6.4-21		
Tape recorder	0-21.5		
Energy Storage			
Storage type			NiCd batteries, one 9 A-hr
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	8192 bps - 600 kbps		STDN, telemetry, command

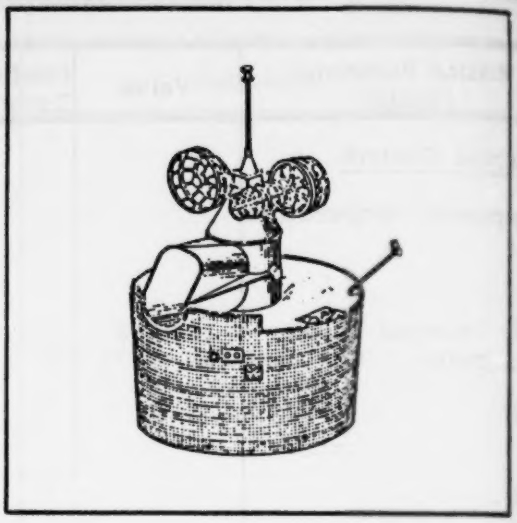
GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Stratospheric Aerosol and Gas Experiment (SAGE) E-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			Passive coatings and bimetallic actuated louvers
Component temperature (K)			
1. Internal components	283-308		
2.			
3..			
Component load (Wt)			
1. Internal components	110		
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

MISSION: Geostationary Orbiting Environmental Satellite (GOES D, E, F) E-2



Status:	Approved
Lifetime:	7 years
Launch and Transfer Vehicles:	Delta 3914 or STS/SSUS
Operational Location:	GEO
Total Mass at Operational Location:	720 kg
Average Operational Power:	320 W

OBJECTIVE:

A geosynchronous environmental satellite providing atmospheric sounding, continuous observations of earth's surface and cloud cover, daytime visible observations, daytime and nighttime infrared observations and space environment monitoring.

DESCRIPTION:

The GOES payload will include a VISSR Atmospheric Sounder (VAS) instrument which is a Visible Infrared Spin Scan Radiometer (VISSR) with atmospheric sounder capability. It will provide for simultaneous imaging in the visible portion of the spectrum with a resolution of 0.9 km and in the infrared (IR) portion of the spectrum with a resolution of approximately 6.9 km. Additionally, radiometric data will be obtained in the earth's atmospheric water vapor and CO_2 absorption bands providing the capability to determine the three-dimensional structure of the atmospheric temperature and humidity. A subsystem to measure energetic particles, solar x-ray flux, and magnetic fields at the satellite will be provided.

CRITICAL TECHNOLOGY NEEDS:

None

INSTRUMENT OR EXPERIMENT COMPLEMENT:

VISSR Atmospheric Sounder (VAS), Space Environment Monitor (SEM)

REFERENCES:

OSTA Program Management Report, 4th Quarter 1978; Execution Phase Project Plan for Geostationary Operational Environmental Satellite, GSFC, December 1979

CONTACTS:

A. J. Cervenka, NASA HQ, EB-8

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Orbiting Environmental Satellite (GOES D, E, F) E-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)			
Total mass (kg)	720		
Instruments	92		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (yr)	7		
Number of spacecraft	3		
Orbit			
Altitude (km)	35786		
Inclination (deg)	1		

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Orbiting Environmental Satellite (GOES, D, E, F) E-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)	28.6		
Peak spin phase	<2.5 µrad		half angle for 6 s
Angle Error	<25 µrad		half angle for 20 min
Type of control system			Spin stabilized at 100 ±5 rpm

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Orbiting Environmental Satellite (GOES D, E, F) E-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	320		Body mounted solar array
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			At least 2 batteries
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			S-band
Uplink (GHz)	2.0		
Downlink (GHz)	1.7		

GLOBAL ENVIRONMENT

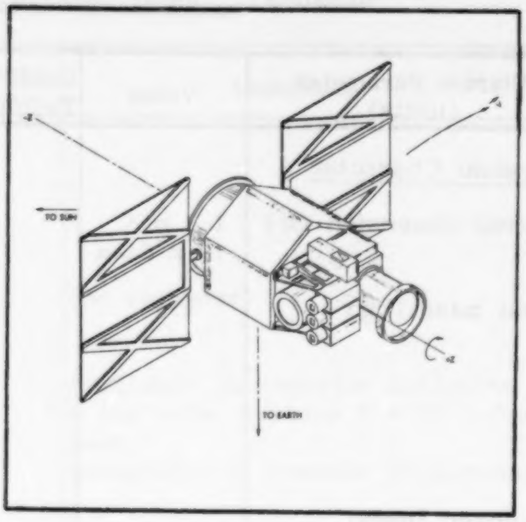
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Orbiting Environmental Satellite (GOES D, E, F) E-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Internal equipment	293 ± 15		
2. Solar array	283-298		163 during equinox eclipse
3..			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

MISSION: Solar Mesosphere Explorer (SME) E-3

Status:	Approved
Lifetime:	At least 1 year design lifetime
Launch and Transfer Vehicles:	SCOUT/July 81
Operational Location:	500 km circular, 97.6° inclination, sun synchronous, 3AM/3PM constant local times
Total Mass at Operational Location:	155 kg
Average Operational Power:	125 W



OBJECTIVE: Provide a comprehensive study of atmospheric ozone and the processes which form and destroy it.

DESCRIPTION: Six instruments will measure the ozone distribution from 25 to 90 km, the solar ultraviolet and proton flux, temperature and pressure from 20 to 75 km, water vapor from 30 to 65 km, nitrogen dioxide from 20 to 40 km, and OH airglow from 50 to 90 km. These measurements will be made available on tape to the scientific community through the National Space Science Data Center. Analysis is expected to yield major new understanding of the mesosphere processes affecting ozone production, destruction, and distribution. The U. of Colorado, Boulder, Laboratory of Atmospheric and Space Physics (LASP) is developing and testing the Observatory Module. JPL is procuring the Spacecraft Base Module. During operation, data recording will be done at the LASP Project Operation Control Center (POCC) at Boulder after relay through Goddard Space Flight Center (GSFC). Commands will be generated at POCC and relayed through GSFC.
The spacecraft will operate by spinning at 5 rpm about its principal axis perpendicular to the orbital plane. The first four instruments share a dual channel spectrometer of Ebert-Fastie optical design, 1/8 m focal length, and which has been built by LASP for the Pioneer Venus Mission. The instantaneous field of view is about 3.5 km at the earth limb or 0.074 degrees, this angle being swept in 2.5 ms.
The ultraviolet monitor has a look direction 45° to the spin axis, and sweeps the sun on each spacecraft rotation.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT:
Ultraviolet ozone experiment, 1.27 μm airglow sensor, visible NO_2 sensor, four channel infrared sensor, solar ultraviolet monitor, proton alarm.

REFERENCES:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.

CONTACTS:

S. Tilford, NASA HQ, EBT-8

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Mesosphere Explorer (SME) E-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			Spacecraft is right octagonal prism about 0.75 m high
Overall dimension (m)	1.1 m × .9 m diam		
Total mass (kg)	155	2	Observatory Instruments - 20 kg Structure, wiring, etc. - 9 kg Spacecraft Structure, mechanisms - 25 kg Attitude control - 11 kg Power - 28 kg Orbit Adjust - 15 kg Communications & data - 27 kg Adapter to SCOUT - 10 kg Contingency - 10 kg
Deployed items, size (m)			
1. 2 solar paddles	1 m × 1 m	1	Each paddle has three sections (see illustration); paddles lie in spin plane, parallel to velocity vector.
2.			
Life			
Flight duration (days)	1 yr	1	Design life: may be exceeded in operation
Number of spacecraft	1	1	
Orbit			
Altitude (km)	500 circ	1	Sun synchronous
Inclination (deg)	96.7	1	

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Mesosphere Explorer (SME) E-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	1.3×10^7	1, SOA	
Storage capacity (bits)	4×10^6	1, SOA	One recorder
I/O rates (bps)	UNK		Available information indicates a low rate, perhaps 5×10^4 b/sec peak
Spacecraft processors/ computers			Housekeeping, command processing
I/O rates (bps)	UNK		
Memory size (bits)	UNK		
Speed (ops/sec)	UNK		
Ground processors/ computers	UNK		Microprocessors will be used at LASP to process incoming data from GFSC for storage and monitoring display
Memory size (bits)	UNK		
Guidance & Attitude Control			
Position accuracy	70 m a track 40 m c track 40 m vertical	1, SOA	These numbers are not obtained from the reference. They are presented as typical for the purposes of the model
Pointing accuracy (mrad)			
Stability (mrad)	±0.6 rms	1, SOA	Estimate of maximum allowed jitter based on 1/2 IFOV size.
Type of control system		1, SOA	Magnetometer, coarse sun sensor, IR horizon scanner provides signals for a magnetic coil control to maintain spin rate and a coil to adjust attitude.

GLOBAL ENVIRONMENT

MISSION·TECHNOLOGY REQUIREMENTS

MISSION: Solar Mesosphere Explorer (SME) E-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power		1	Solar cell array/battery
Average power consumed (kWe)	0.135	1	
Peak power consumed (kWe)	0.160	1	When charging batteries on day side;includes margin
Power breakdown (We)			Average powers
Science	27		
Attitude control	8		
Communications	10		
Data handling	8		
Thermal control	10		
Battery charging	72		
Energy Storage			
Storage type	UNK		
Energy/cycle (J)	UNK		
Communications		1	Direct to NASA ground stations, thence to LASP
Link, type of data and rate (Mbps)	S band	1, SOA	STDN TDRSS, NASCOM

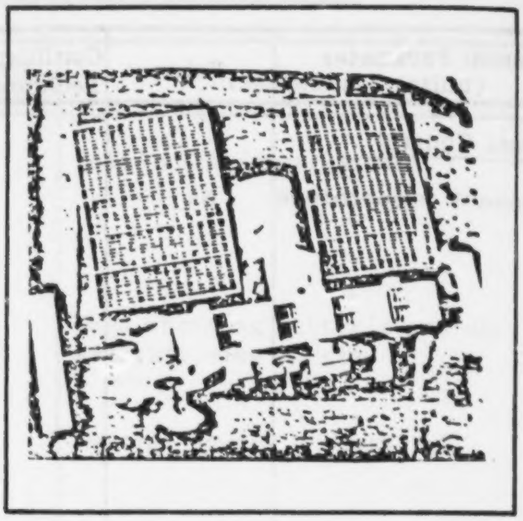
GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Mesosphere Explorer (SME) E-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			Rotation minimizes thermal imbalance; supplemental heaters provided (10 W)
Component temperature (K)	NA		
1.			
2.			
3..			
Component load (Wt)	NA		
1.			
2.			
3.			
Propulsion	NA		Launched directly into final orbit, then allowed to decay and reenter the atmosphere
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

MISSION: Earth Radiation Budget Satellite E-4



Status:	Approved
Lifetime:	2 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	600 km
Total Mass at Operational Location:	TBD
Average Operational Power:	109 W (instruments only)

OBJECTIVE:

To develop a global system for measuring the components of the earth's radiation budget (incoming solar radiation, outgoing reflected and emitted radiation). To apply the data in scientific investigations aimed at improving our understanding of climate change.

DESCRIPTION:

TBD

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Earth radiation budget experiment, Stratospheric Aerosol and Gas Experiment II, Halogen Occultation Experiment

REFERENCES: Execution Phase Project Plan Earth Radiation Budget Experiment (ERBE), Stratospheric Aerosol and Gas Experiment II (SAGE II), Halogen Occultation Experiment (HALOE) On-Orbit Radiation Budget Satellite, Appendix B - Experiments, LaRC, February 1979

CONTACTS:

Dick Diller, NASA HQ, Code EB-8

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Earth Radiation Budget Satellite E-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)	TBD		
Total mass (kg)	TBD		
ERBE	55		Total 160 kg
SAGE	30		
HALOE	75		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	720		ERBE will also be carried on two TIROS-N missions
Number of spacecraft	1		
Orbit			
Altitude (km)	600		Circular
Inclination (deg)	46		

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Earth Radiation Budget Satellite E-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	TBD		
Storage capacity (bits)			
I/O rates (bps)			ERBE: 1120 bps; HALOE: 4098 bps SAGE II: 6144 bps
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)	±250 m ±100 m		Along and cross track Altitude
Pointing accuracy (mrad)	±35 ±17		Yaw Pitch and roll
Stability (mrad)			
Type of control system			

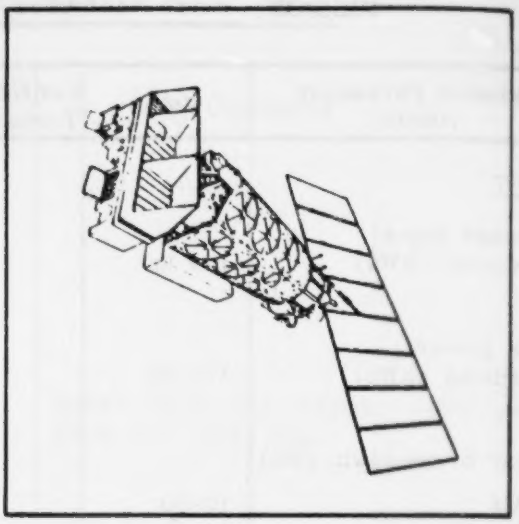
GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Earth Radiation Budget Satellite E-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	109 We		
Peak power consumed (kWe)	195 We		
Power breakdown (We)			
ERBE	10-80		
Sage II	10-40		
HALOE	40-75		
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TBD		

MISSION: NOAA A-G/TIROS-N



Status:	Approved
Lifetime:	2 years
Launch and Transfer Vehicles:	Atlas F
Operational Location:	830 km
Total Mass at Operational Location:	740 kg
Average Operational Power:	460 W

OBJECTIVE:

Develop a third-generation operational prototype satellite to be incorporated into the operational system upon depletion of ITOS spacecraft. NOAA A-G will meet the stated requirements of Global Atmospheric Research Program (GARP) and future needs of the National Operational Environmental Satellite System (NOESS).

DESCRIPTION:

The satellite instrument complement will provide high resolution measurement of atmospheric vertical temperature profiles for improved, long-range weather predictions; a balloon and buoy tracking capability for determination of winds and ocean currents; high resolution temperature data of cloud tops or earth surface temperature; global day and night imaging of cloud cover; global ozone monitoring starting with NOAA-F.

CRITICAL TECHNOLOGY NEEDS:

None

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Advanced Very High Resolution Radiometer, High Resolution Infrared Sounder, Microwave Sounding Unit, Space Environment Monitor, Solar Backscatter Ultra-Violet Spectrometer, Stratospheric Sounding Unit

REFERENCES: OSTA Program Management Report, 4th Quarter 1978

CONTACTS:

A. J. Cervenka, NASA HQ, EB-8

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: NOAA A-G/TIROS-N E-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)			
Total mass (kg)	740		
Instruments	230		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	730		
Number of spacecraft	8		
Orbit			
Altitude (km)	830 ± 90		Sun synchronous
Inclination (deg)	98.77		

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: NOAA A-G/TIROS-N E-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			3 axis

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: NOAA A-G/TIROS-N E-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	460		
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			

MISSION: National Oceanic Satellite System (NOSS) E-6

Status:	Planned
Lifetime:	3 year primary mission life
Launch and Transfer Vehicles:	Shuttle/Teleoperator Retrieval System
Operational Location:	700-km circular 87° (nominal)
Total Mass at Operational Location:	3816 kg
Average Operational Power:	2200 W

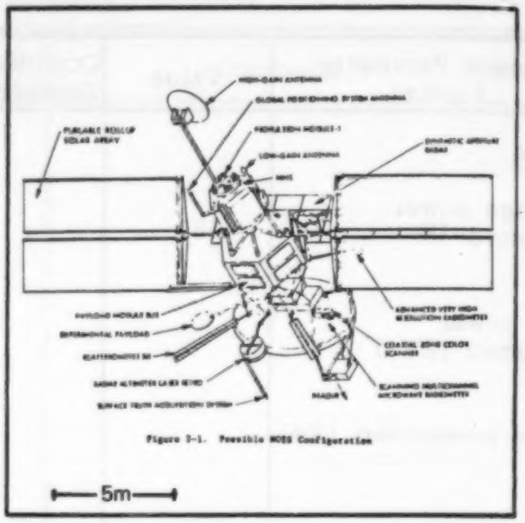

HIGH-GAIN ANTENNA
GLOBAL POSITIONING SYSTEM ANTENNA
FURLABLE ROLLUP SOLAR ARRAY
LOW-GAIN ANTENNA
SYNTHETIC APERTURE RADAR
PAYLOAD MODULE BUS
EXPERIMENTAL PAYLOAD
SCATTEROMETER
RADAR ALTIMETER LASER RETRO
SURFACE TRUTH ACQUISITION SYSTEM
ADVANCED VERY HIGH RESOLUTION RADIOMETER
COASTAL ZONE COLOR SCANNER
SCANNING MULTICHANNEL MICROWAVE RADIOMETER
5m

Figure 3-1. Possible NOSS Configuration

OBJECTIVE: Provide a limited operational demonstration of global sea surface observation capability to describe ocean processes, ice dynamics, and coastal processes.

DESCRIPTION: The National Oceanic Satellite System (NOSS) is a limited operational demonstration proposed as a joint effort by NASA, NOAA, and DoD. The system payload is a follow-on to Seasat, and is intended to validate current concepts of satellite measurement of oceanic parameters required to improve and sustain operational oceanic analysis and prediction programs.
NOSS is envisioned as consisting of two satellites launched 10 months apart, one operational and one stored in orbit. Following Shuttle launch to a 280-km orbit, the teleoperator system will take the spacecraft to a 600-900 km circular orbit and then return to rendezvous with the Shuttle. The teleoperator system will also be used to refurbish and retrieve the spacecraft. All data will be relayed in real time by means of the TDRSS to White Sands, New Mexico. After processing and formating, the data will be transmitted to the user agencies via Domsat links or landlines.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Scatterometer, radar altimeter, scanning multichannel microwave radiometer, coastal zone color scanner, advanced very high-resolution radiometer.

REFERENCES:

National Oceanic Satellite System, joint effort by NASA, NOAA, DoD, 23 March 1979.

CONTACTS:

D. Broome, NASA Headquarters, Code EB-8, 755-8623

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: National Oceanic Satellite System (NOSS) E-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)	10.7 x 4.5 dia	2, SOA	
Total mass (kg)	3816-5150	2	25% growth from base line desired
Instrument	1491	2	
Power	1398	2	
MMS bus	851	2	
Propellant	76	2	
Deployed items, size (m)			
1. Parabolic dish	4 dia	2, SOA	Also 4 solar arrays (FRUSA)
2. Booms	15	2, SOA	
Life			
Flight duration (days)	3 years	2	
Number of spacecraft	2		One backup; 9 months between successive launches
Orbit			Earth synchronization
Altitude (km)	600-900	2	Circular orbit, 700 nominal
Inclination (deg)	85-100	2	87 nominal

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: National Oceanic Satellite System (NOSS) E-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	2.7×10^{11}	2, SOA	Via TDRSS
Storage capacity (bits)	9×10^{8}	2, SOA	2 tape recorders
I/O rates (bps)	32-50 K 1.5-10 M	2, SOA 2, SOA	Low rate } TDRSS High rate } TDRSS
Spacecraft processors/ computers			Data processing system (NSSC-1)
I/O rates (bps)	2-64 K	2, SOA	32 K nominal
Memory size (bits)	576 K	2, SOA	
Speed (ops/sec)	0.2 M	2, SOA	Add time = 5 µsec, 18 bit word
Ground processors/ computers			Data preprocessing, NOSS user outputs, analysis, etc.
Memory size (bits)	5×10^{11}	2, SOA	Daily, number of days TBD
Guidance & Attitude Control			2 star trackers; fine and coarse sun sensor
Position accuracy (km)	10 cm	2, REV	Required for altimeter, ±5 m available from GPS
Pointing accuracy (mrad)	1.7-17.4	2, EV	1.7 nominal
Stability (mrad)	3.4-17.4	2, SOA	8.7 nominal
Type of control system			

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: National Oceanic Satellite System (NOSS) E-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	2.2	2, EV	
Peak power consumed (kWe)	ND		
Power breakdown (We)			
Instruments	1167	2	
Power management	324	2	
MMS bus	306	2	
Energy Storage			
Storage type			6 50 A-hr NiCd batteries
Energy/cycle (J)	1790	2, SOA	18% depth of discharge
Total cycles	15,900	2, SOA	
Communications			
Link, type of data and rate (Mbps)	32-50 kbps 1.5-10 Mbps 120 Mbps	1, SOA	TDRSS interface Domsat interface

GLOBAL ENVIRONMENT

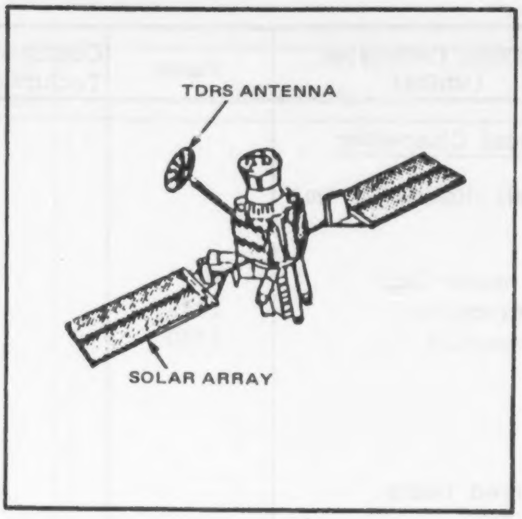
MISSION TECHNOLOGY REQUIREMENTS

MISSION: National Oceanic Satellite System (NOSS) E-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1.			
2.			
3..			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	14.2	2, SOA	Monomethyl hydrazine
Thrust level (N)	0.9 2.2	2, SOA	Control torques ΔV changes
I_{sp} of stages (sec)	Varies		

MISSION: Upper Atmospheric Research Satellite (UARS) E-7

Status:	Planned
Lifetime:	18 months
Launch and Transfer Vehicles:	Shuttle
Operational Location:	500 km, 56° inclination
Total Mass at Operational Location:	
Average Operational Power:	1000 W



OBJECTIVE: The initial mission of the Upper Atmosphere Research Satellite will study the radiation, chemistry, and dynamics of the upper atmosphere at low, mid, and moderately high altitudes and the coupling between these properties in order to determine the seasonal correlations. Interaction and coupling between atmospheric regions and processes will be emphasized on this mission.

DESCRIPTION: The satellite will be placed in a 56° inclination orbit at an altitude of about 500 km, providing adequate geographic coverage for many of the scientific requirements. Processed scientific data will be transmitted to earth via TDRSS. The retrieval, reuse, and possible in-orbit refurbishment of the satellite will be accomplished by the Shuttle in conjunction with the spacecraft's on-board propulsion system. As of May 1980 the instrument list below is tentative. Final selection of instruments will be announced in the summer of 1980.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT: UV spectrometer, Doppler interferometer, modulated gas cell radiometer, filter radiometer, Nadir emission radiometer, emission radiometer, occulation radiometer, UV airglow emission spectrometer, 1.27 μm-emission spectrometer, far IR spectrometer, laser heterodyne radiometer, microwave limb sounder.

REFERENCES:

Upper Atmosphere Research Satellite Program, Final Report of the Science Working Group, JPL Document No. 78-54, July 1978.

CONTACTS:

R. Seals, NASA Headquarters, EBT-8

GLOBAL ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Upper Atmospheric Research Satellite (UARS) E-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)			
Total mass (kg)	ND		
Instruments	1375		
Cryogenics	2330		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	548		
Number of spacecraft	1		
Orbit			
Altitude (km)	500		
Inclination (deg)	56		

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Upper Atmospheric Research Satellite (UARS) E-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)	10^8		
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)	0.17		General pointing requirement
Attitude accuracy (mrad)	0.05		
Stability (mrad)			
Attitude drift (mrad/ sec)	3.5×10^{-4}		
Type of control system			

GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Upper Atmospheric Research Satellite (UARS) E-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	1		
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			TDRSS

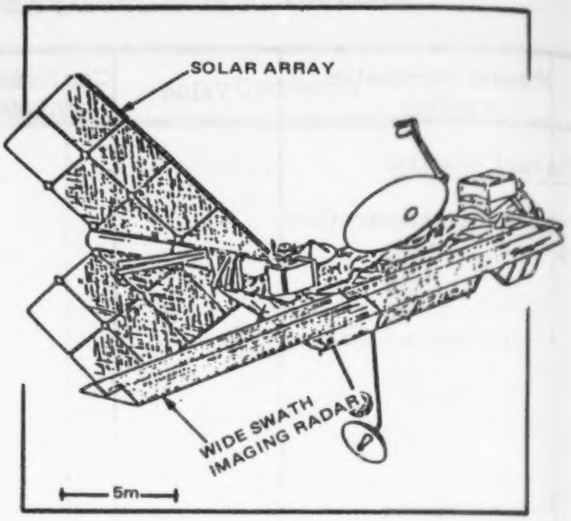
GLOBAL ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Upper Atmospheric Research Satellite (UARS) E-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Cryogenic cooling	4		18 months duration
2.			
3..			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			Propulsion system used for on-orbit control and return to Shuttle
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

MISSION: NOSS Research Program E-8



Status: Planned

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location: ND

Average Operational Power: ND

OBJECTIVE: To permit the study and characterization of the polar regions. Specifically, sea ice forms; ocean temperature, velocity and salinity; ice sheet forms and snow cover.

DESCRIPTION:

The NOSS Research Program replaces the earlier Climate Research Program, whose objectives were to be satisfied using a satellite called ICEX, a system no longer being considered by OSTA. The instrument complement shown below is the set that was being considered for ICEX. Present OSTA plans call for a large antenna multifrequency microwave radiometer and a scatterometer to be flown on NOSS (E-6). Subsequent mission systems and instruments will be investigated under the NOSS Research Program.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Large antenna multifrequency microwave radiometer (LAMMR), scatterometer, wide swath imaging radar (WSIR), ice elevation altimeter system (IEAS), polar ice mapping radiometer (PIMR).

REFERENCES:

Preliminary Execution Phase Project Plan for Ice Experiment, Goddard Space Flight Center

CONTACTS:

R. Schiffer, NASA HQ, EB-8

GLOBAL ENVIRONMENT

MISSION: Ocean Circulation Mission - Topography Experiment (TOPEX) E-9

Status:	Planned
Lifetime:	3-5 years
Launch and Transfer Vehicles:	Shuttle/IUS
Operational Location:	
Total Mass at Operational Location:	
Average Operational Power:	

OBJECTIVE: The objective of the topography experiment (TOPEX) is to map the surface topography of the ocean, which--when combined with knowledge of the geoid (obtained from Gravsat and ship gravity surveys)--will then enable the absolute value of the surface geostrophic current to be determined. This, plus ship-derived subsurface measurements of the density structure of the ocean, will enable the general circulation to be determined. In addition to surface topography, the altimeter will provide surface roughness along nadir--from which surface wind speed and significant wave heights can be determined; all of this data will permit a demonstration of usefulness for ocean applications. Definition studies will be conducted during FY 1980 for TOPEX.

DESCRIPTION:

CRITICAL TECHNOLOGY NEEDS:

Precise orbit determination good to 10 cms would add immense value to TOPEX.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Radar altimeter and two-channel microwave radiometer (to permit removal of atmospheric effects on propagation of altimeter signal).

REFERENCES:

CONTACTS:

Dr. Robert Chase, NASA HQ, EBC-7, 755-8617
Dr. Stan Wilson, NASA HQ, EBC-8, 755-8617

MISSION: Operational Meteorology Satellite E-10

Status: Planned

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

NOTHING DEFINED AT THIS TIME

OBJECTIVE:

DESCRIPTION:

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

CONTACTS:

W. Bishop, NASA HQ, EB-8

GLOBAL ENVIRONMENT

MISSION: Ocean Research (SAR) E-11

Status: Candidate

Lifetime: 2-3 years

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE:

The objective of this ocean research mission is to deploy a spaceborne synthetic aperture radar for purposes of monitoring oceanic and ice features such as: position of current boundaries, deformation of sea ice field, effects of atmospheric forcing, etc.

DESCRIPTION:

Definition studies must necessarily await availability of processor and versatile SAR noted below, as well as result of basic investigations of what the features noted in SAR imagery actually are likely to be.

CRITICAL TECHNOLOGY NEEDS: Real-time SAR image processor (to enable processing time to be equivalent to data gathering time); versatile SAR for deployment from both aircraft and shuttle (to enable determination of SAR frequency, polarization, and depression angle).

INSTRUMENT OR EXPERIMENT COMPLEMENT:

SAR, plus other instruments as needed and/or appropriate

REFERENCES:

CONTACTS:

Dr. Stan Wilson, NASA HQ, EBC-8, 755-8617
Dr. Robert Chase, NASA HQ, EBC-8, 755-8617

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Global Environment Instruments

EI-1	4-Channel Spectral Radiometer (SAGE)
EI-2	Gas Filter Correlation Infrared Analyzer
EI-3	Earth Radiation Budget Experiment
EI-4	Stratospheric Aerosol and Gas Experiment II
EI-5	Halogen Occultation Experiment
EI-6	Atmospheric Trace Molecules Observed by Spectroscopy
EI-7	Nighttime/Daytime Optical Survey of Lightning and Convective Phenomena Experiment (NOSL)
EI-8	Active Cavity Radiometer
EI-9	Space Environment Monitoring (SEM) System
EI-10	VISSR Atmospheric Sounder (VAS)
EI-11	High Resolution Infrared Radiation Sounder (HIRS)
EI-12	Microwave Sounding Unit (MSU)
EI-13	Stratospheric Sounding Unit (SSU)
EI-14	Solar Backscatter Ultraviolet Spectrometer (SBUV)
EI-15	Ultraviolet Ozone Experiment
EI-16	1.27 μm Airglow Sensor
EI-17	Visible Nitrogen Dioxide Experiment
EI-18	Four-Channel Infrared Sensor
EI-19	Solar Ultraviolet Monitor
EI-20	Proton Alarm
EI-21	Vertical Temperature Profile Radiometer
EI-22	Advanced Very High Resolution Radiometer (AVHRR)
EI-23	Dual Frequency Scatterometer
EI-24	Dual Antenna Multibeam Altimeter
EI-25	Large Antenna Multifrequency Microwave Radiometer (LAMMR)

Global Environment Instruments (Cont.)

EI-26	Scatterometer (SCAT)
EI-27	Scanning Multichannel Microwave Radiometer (SMMR)
EI-28	Radar Altimeter (ALT)
EI-29	Coastal Zone Color Scanner (CZCS)
EI-30	Solar UV Spectrometer
EI-31	Doppler Interferometer
EI-32	Modulated Gas Cell Radiometer
EI-33	Filter Radiometer
EI-34	Nadir Emission Radiometer
EI-35	Emission Radiometer
EI-36	Occultation Radiometer
EI-37	UV Airglow Emission Spectrometer
EI-38	1.27 μm Emission Spectrometer
EI-39	Far IR Spectrometer
EI-40	Laser Heterodyne Radiometer
EI-41	Microwave Limb Sounder
EI-42	LIDAR
EI-43	Radar Altimeter (ALT)
EI-44	2-Channel Microwave Radiometer
EI-45	Cryogenic Limb Scanning Interferometer Radiometer
EI-46	Spaceborne Meteorological Radar
EI-47	Lidar Pressure and Temperature Sensor
EI-48	Microwave Pressure Sounder
EI-49	Standard Ozone Sounding Unit (SOSU)
EI-50	Laser Absorption Spectrometer (LAS)
EI-51	Correlation Interferometry for Measurement of Atmospheric Trace Species (CIMATS)

Global Environment Instruments (Cont.)

EI-52	Temperature Humidity Infrared Radiometer (THIR)
EI-53	Atmospheric Emission Photometric Imaging (AEPI)
EI-54	Advanced Meteorological Sounding Unit
EI-55	Advanced Meteorological Temperature Sounder
EI-56	High Resolution Doppler Imager
EI-57	High Resolution Solar Spectrometer
EI-58	Atmosphere General Circulation Experiment
EI-59	Lightning Mapper
EI-60	Cloud Radiation Experiment
EI-61	Doppler Geostationary Imager
EI-62	Salinity Radiometer
EI-63	Ice Sounder
EI-64	Local Wave Spectra Sensor
EI-65	Laser Altimeter
EI-66	Ocean Synthetic Aperture Radar
EI-67	Pushbroom Radiometer

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INSTRUMENT: 4-Channel Spectral Radiometer (SAGE) EI-1

STATUS: Approved

CARRIER: Stratospheric Aerosol and Gas Experiment (SAGE)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 6.4-21

Mass (kg): 27.7

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

4-channel radiometer to determine the spatial distribution of stratospheric aerosols and ozone on a global scale. In particular: (a) to develop a satellite-based remote sensing technique for measuring stratospheric aerosols and ozone; (b) to map vertical extinction profiles of stratospheric aerosols and ozone; and (c) to investigate aerosol optical properties.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Ozone extinction coefficient
  Accuracy: ≤5%
Aerosol extinction coefficient
  Accuracy: ≤10%
Nitrogen dioxide
  Accuracy: ≤30%
Raleigh molecular extinction
  Accuracy: ≤10%

ASSOCIATED RANGES AND/OR RESOLUTION:

Vertical resolution: 1 km
Altitude range: 10-100 km above earth horizon
Radiometer resolution: 3000:1
SNR: 1.5×10^5 (1 μm)
Wavelength (μm): 0.385, 0.45. 0.6, 1.0
Detector operating temperature: 292 K-303 K
Scan rate: 15 km/sec
Sampling rate: 64/sec
Information bandwidth: 1 Hz/km channel

COMMENTS:

SOURCE/CONTACT:

Dick Diller, NASA HQ, EB -8
Stratospheric Aerosol and Gas Experiment of the Applications Explorer Missions Program. GSFC

INSTRUMENT: Gas Filter Correlation Infrared Analyzer EI-2

STATUS: Approved

CARRIER: Shuttle/Spacelab-3 (MAPS)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.75 × 0.75 × 0.75

Mass (kg): 64

Power Requirement (We): 105

Data Rate (kbps): 0.05

PRINCIPAL PURPOSE AND FEATURES: To measure the latitudinal and longitudinal distribution of carbon monoxide in the middle troposphere and to verify the transport of carbon monoxide from the northern hemisphere to the southern hemisphere. The instrument to be used to acquire the required data is a ruggedized version of the MAPS brassboard instrument that was developed under the NIMBUS G program. It is a gas filter correlation instrument that represents a further evolution of the laboratory type nondispersive infrared analyzers.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

CO sensing.

ASSOCIATED RANGES AND/OR RESOLUTION:

Spectral range: 4.5-4.8 μm
Sensitivity: 1.7×10^{-8} W/sr-cm^2
Temporal bandwidth: 0.14 Hz
FOV: 0.076 rad
3 detectors: PbSe
Temperature: 195 K (Thermoelectric cooling)

Data sample interval
- Channels: 1 sec
- Temperature: 15 sec

Nadir viewing
- Accuracy: 0.087 rad
- Stability: 0.29 mrad/sec

COMMENTS:

SOURCE/CONTACT: E. Prior, NASA HQ, EBT-8; S.M. Beck, NASA/LaRC 804/827-2576
Measurement of Air Pollution from Shuttle Experiment, proposal to NASA HQ for OFT Space Shuttle Mission, NASA LaRC, 3 December 1976

INSTRUMENT: Earth Radiation Budget Experiment EI-3

STATUS: Approved

CARRIER: Earth Radiation Budget Satellite

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 50, avg.

Mass (kg): 50

Data Rate (kbps): 1.120

PRINCIPAL PURPOSE AND FEATURES:

To develop a global system for measuring the components of the earth's radiation budget. To apply the data in scientific investigations to improve our understanding of climate change.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Solar flux density
  Accuracy: 0.5%
Earth albedo
  Accuracy: (W/m^2)
  Global: 1
1000-km zones: 2-12
Equator to pole gradient: 4
1000-km regions: 2-15
250-500 km regions: 2-14

ASSOCIATED RANGES AND/OR RESOLUTION:

Spectral range: 0.2-50+ μm

COMMENTS:

Wide/medium FOV measurements: 5 channels
Scanner measurements (3° IFOV): 3 channels

SOURCE/CONTACT: Dick Diller, NASA HQ, EB-8
Execution Phase Project Plan Earth Radiation Budget Experiment (ERBE), Stratospheric Aerosol and Gas Experiment II (SAGE II), Halogen Occulation Experiment (HALOE) On-Orbit Radiation Budget Satellite, Appendix B - Experiments, LaRC, February 1979

INSTRUMENT: Stratospheric Aerosol and Gas Experiment II EI-4

STATUS: Approved

CARRIER: Earth Radiation Budget Satellite

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 10-40

Mass (kg): 30

Data Rate (kbps): 6.144

PRINCIPAL PURPOSE AND FEATURES:

7-channel radiometer to determine the spatial distribution of stratospheric aerosols and ozone on a global scale. In particular: (a) to develop a satellite-based remote sensing technique for measuring stratospheric aerosols and ozone; (b) to map vertical extinction profiles of stratospheric aerosols and ozone: and (c) to investigate aerosol optical properties.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Radiometer
  Resolution: 4000:1
Ozone
  Accuracy: $\leq 5\%$
Aerosol
  Accuracy: $\leq 10\%$

Molecular Rayleigh extinction
  Accuracy: $\leq 30\%$
Nitrogen dioxide
  Accuracy: $\leq 10\%$
Altitude
  Resolution: 1 km

ASSOCIATED RANGES AND/OR RESOLUTION:

Altitude range: 10-100 km above horizon
Wavelength (μm): 0.385-1.0
Detector operating temperature: 292 K-303 K
Scan rate: 15 km/sec
Sampling rate: 64/sec
SNR: 1.5×10^5
Information bandwidth: 1 Hz/km channel

COMMENTS:

SOURCE/CONTACT: Dick Diller, NASA HQ,EB-8
Execution Phase Project Plan Earth Radiation Budget Experiment (ERBE), Stratospheric Aerosol and Gas Experiment II (SAGE II), Halogen Occultation Experiment (HALOE) On-Orbit Radiation Budget Satellite, Appendix B-Experiments, LaRC, February 1979

INSTRUMENT: Halogen Occultation Experiment EI-5

STATUS: Approved

CARRIER: Earth Radiation Budget Satellite, Spacelab 3

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.59 m^3

Power Requirement (We): 40-75

Mass (kg): 81-95

Data Rate (kbps): 4.078

PRINCIPAL PURPOSE AND FEATURES:

To measure stratospheric profiles of halogens, their photochemical reactions and interaction wtih ozone. HF, HCI, CH_4, and NO are measured by gas correlation spectroscopy. CO_2, H_2O, O_3, and CF_2Cl_2 are measured by broadband radiometry.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Ozone-cloride chemistry constituents.

Species	Accuracy (%)	Resolution (km)	λ(μm)	Detector type	Detector temp. (K)
NO	10	400H/2V	5.2	HgCdTe	200
HF	10	400H/2V	2.4	InAs	230
CH_4	15	400H/2V	3.5	InAs	230
HC1	10	400H/2V	3.4	InAs	230
H_2O	15	400H/2V	6.5	Thermistor Bolometers	
CF_2Cl_2	10	400H/2V	10.8		
CO_2	15	400H/2V	2.8		
O_3	10	400H/2V	9.7		

ASSOCIATED RANGES AND/OR RESOLUTION:

Optical parameters

Parameter	Gas Correlation Channel	Radiometer Channel
Telescope	Centrally obscured cassegrain, 6" dia primary, 96 cm EFL, f/6	
Clear aperture	81 cm^2, aperture stop limited	101 cm^2, baffle limited
Field-of-view	Reflective field stop Elevation: 2 $\widehat{\text{min}}$ (0.587 mr) Azimuth: 6.23 $\widehat{\text{min}}$ (1.826 mr)	
Chopping	Disc type Transmission @ 150 Hz Reflection @ 150 Hz	
Filter bandwidth	0.91 Hz	
Processing noise bandwidth	0.42 Hz, synchronous detection	

INSTRUMENT: Halogen Occultation Experiment (Cont.) EI-5

ASSOCIATED RANGES AND/OR RESOLUTION (Cont.):

	Gas Correlation Channel	Radiometer Channel
Sampling rate	8 samples/sec	
Quantization	12 bits (11 numerical + 1 sign)	
Intrinsic filter	UV blocking ZnSe	
Reference source	1000°K blackbody 300 Hz modulation	N/A
Noise equivalent modulation	<20 ppm all bands	N/A
Noise equivalent irradiance	$<2.6 \times 10^{-6}$ Ns (4800°K)	$<7.7 \times 10^{-4}$ Ns (4800°K)
Calibration positions	3 N.D filters 8 gas cells	3 N.D. filters
Optical throughput	0.013 to 0.041	0.11 to 0.17
No. of gas detection channels	4	4
Detector	HgCdTe & InAs	Thermistor bolometers
Spatial frequency recovery	>0.25 cycle/km	>0.25 cycle/km

COMMENTS: Pointing and tracking parameters

Gimbal range	±185° azimuth +9° to -26° elevation
Slew rate	1.4°/sec
Prepositioning accuracy	±0.4°
Coarse sun sensor FOV	±10° azimuth ±10° elevation
Fine sun sensor FOV	±0.57° elevation
Acquisition time	<3 sec
Tracking rates	≤0.072°/sec azimuth ≤0.072°/sec elevation
Tracking error (RMS)	≤0.33 $\overset{\frown}{\text{min}}$ azimuth ≤0.47 $\overset{\frown}{\text{min}}$ elevation
Pointing knowledge (short term)	≤15 $\overset{\frown}{\text{sec}}$ azimuth ≤6 $\overset{\frown}{\text{sec}}$ elevation

SOURCE/CONTACT: Ray Arnold, NASA HQ, EB-8

Halogen Occultation Experiment (HALOE) On-Orbit Radiation Budget Satellite, Appendix B Experiments, February 1979

Halogen Occultation Experiment Instrument, PDR Package, MSFC/TRW, November 1979

INSTRUMENT: Atmospheric Trace Molecules Observed by Spectroscopy EI-6

STATUS: Approved

CARRIER: Spacelab 1 and 3

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.5 m^3

Power Requirement (WE): 435

Mass (kg): 195

Data Rate (kbps): 16

PRINCIPAL PURPOSE AND FEATURES:

Monitor environmental quality by surveying the stratosphere for trace constituents to measure their volume mixing ratios and vertical profiles and to clarify the nature of the stratospheric infrared background to optimize the design of future instruments. The ATMOS optical head consists of a sun tracker, a telescope and an interferometer.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Upper atmospheric structure
  Range: 2-16 μm
  Spectral resolution: 0.02 cm^{-1}

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Continuous scan Fourier spectrometer. Detector is a HgCdTe type cooled to liquid nitrogen temperature.

SOURCE/CONTACT: L. L. Simmons, JPL, (213) 354-6336
Spacelab Mission 1 Experiment Description, MSFC, NASA TM-78173, May 1978

INSTRUMENT: Nighttime/Daytime Optical Survey of Lightning and Convective Phenomena Experiment (NOSL)

EI-7

STATUS: Approved

CARRIER: Shuttle - hand held unit
OFT-2

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.028 m^3

Power Requirement (We): 25 (max)
16.8 (nominal)

Mass (kg): 15.75

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To conduct a daytime and nighttime orbital survey of selected targets of opportunity for severe storms and lightning phenomena using a cine camera and optical sensor. The survey will also collect data on the number, duration, and flash intensity of lightning contained within the convective storm cells and provide additional data on the convective motions in the upper parts of the penetrating cloud cells.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Thunder storm activity of interest: long lightning discharges; unusual lightning in tornado-producing storms, electrical discharges in the clear air above thunderstorms; changes in the reflection of sunlight from upper part of thunder cloud as a result of electrical reorientation; cloud circulation; maritime thunder storms; warm cloud electrification; electrical activity in hurricanes and typhoons; lightning in volcanic eruptions; relationship between cloud types and lightning; spectroscopic observations lightning.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This instrument is a slightly modified 16 mm Maurer data acquisition camera and a photo cell sensor system.

SOURCE/CONTACT: J. Dodge, NASA HQ, EBT-8

Nighttime/Daytime Optical Survey of Lightning and Convective Phenomena Experiment (NOSL), NASA TM-78-261, February 1980

INSTRUMENT: Active Cavity Radiometer EI-8

STATUS: Approved

CARRIER: Pallet
Spacelab-1

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.053 m^3

Power Requirement (WE): 13 peak

Mass (kg): 20

Data Rate (kbps): 0.168

PRINCIPAL PURPOSE AND FEATURES:

Measurement of total solar irradiance to determine the magnitude and direction of possible variations in total solar optical energy output. The data will be used to study the physical behavior of sun and earth climatology. The instrument consists of a triad of two right circular conical cavity detectors.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Electrically self-calibrating, cavity detector pyrheliometer capable of defining the absolute radiation scale with an accuracy better than 0.2%. Field of view of each unit limited to 5°.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

The ACR operates in a differential mode.

SOURCE/CONTACT: Dr. R. Wilson, JPL, (213) 354-3529
Spacelab Mission 1 Experiment Descriptions, MSFC, NASA TM-78173, May 1978

INSTRUMENT: Space Environment Monitoring (SEM) System EI-9

STATUS: Approved

CARRIER: GOES (D, E, F)
NOAA A-G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To provide direct measurement of important effects of solar activity in such a manner that data will be available continuously in realtime for use in generation of advisory or warning messages. The data will also be available for other uses, such as forecasting and operational research. The SEM System is divided into three subsystems: The Solar Energetic Particles Subsystem, which monitors solar particle radiation; the Solar X-Ray Sensor Subsystem, which monitors solar X-Ray emissions; and the Magnetometer Subsystem, which monitors magnetic field variations.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

The Solar Energetic Particles Subsystem consists of three detector assemblies, each of which covers only limited regions of the overall energy spectrum. The first two detectors monitor protons in seven energy ranges between 0.8 and 500 MeV, alpha particles in six ranges between 4 and 400 MeV, and there is also a channel for measuring electrons in the 500 keV range. The third detector assembly is the High Energy Proton and Alpha Detector (HEPAD) which monitors protons in four energy ranges above 370 MeV, and alpha particles in two energy ranges above 640 MeV/nucleon.

In the Solar X-Ray Sensor Subsystem, the ranges and minimum useful threshold sensitivity are 0.5-3 Å, 10^{-6} ergs cm^{-2} sec^{-1}; and 1-8 Å, 10^{-5} ergs cm^{-2} sec^{-1}, with a dynamic range of 10^4.

The Magnetometer Subsystem has a range of ±400 gamma (without saturation) and a resolution of 0.1 gamma over a range of ±50 gamma.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Execution Phase Project Plan For Geostationary Operational Environmental Satellite (GOES D, E, F) Revision 2
A. J. Cervenka, EB-8

INSTRUMENT: VISSR Atmospheric Sounder (VAS) EI-10

STATUS: Approved

CARRIER: GOES (D, E, F)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The VISSR Atmospheric Sounder (VAS) is an extension of the original VISSR imaging capability and includes additional thermal bands for the determination of atmospheric temperature at various altitude layers by spectral selection in the CO_2 absorption bands. Water content is also determined at several altitudes in the H_2O absorption bands. In addition, the cloud and Earth surface temperature is measured in the 3.7 micrometer band for improved temperature values. The added capabilities of VAS provide the additional atmospheric measurements which enable extensive research in atmospheric science from the geostationary vantage point.

Parameter flexibility including spectral band selection, spatial resolution signal-to-noise (S/N) ratio and geographic location are incorporated into the sounding or multispectral imaging modes to provide measurements which best meet the needs of the research scientist. There are three distinct operational modes: the VISSR mode, the Dwell-sounding mode, and the Multispectral Imaging mode. The VISSR operating mode is the same as the regular VISSR system. Both day and night cloud cover imagery will be possible as with VISSR. This is the NOAA operational mode. The Dwell-sounding mode is the mode for the VAS experiment, and the Multispectral Imaging mode can provide normal VISSR imaging plus data in any two selected spectral bands having a spatial resolution of 13.8 km. The MSI mode takes advantage of small HgCdTe detectors, and by using their data, a complete infrared map may be produced when they are operated every other scan line.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: In the VISSR mode the FOV is 6.9 km with a visible channel resolution of 0.9 km. The Dwell-sounding mode covers the range 680 cm^{-1} (14.7 μm) through 2535 cm^{-1} (3.9 μm), and in the spectral range of 703 cm^{-1} (14.2 μm) through 1490 cm^{-1} (6.7 μm), either the 6.9 km or the 13.8 km resolution detectors can be selected. The MSI mode has a spatial resolution of 13.8 km.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Execution Phase Project Plan for Tiros-N and NOAA-A through G Operational Follow-On Satellites (7)

A. J. Cervenka, EB-8

INSTRUMENT: High Resolution Infrared Radiation Sounder (HIRS) EI-11

STATUS: Approved

CARRIER: NOAA-A through G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

HIRS is a 20-channel, discrete-stepping, line-scan instrument designed to measure scene radiance in 20 spectral bands from 0.69 to 15 μm. From these measurements, the vertical temperature profile from the earth's surface to about 40 km can be determined. The HIRS has an optical field of view of 1.25° in all channels, viewing 12 long wave, 7 short wave, and 1 visible spectral region with mercury cadmium telluride, indium antimonide, and silicon detectors, respectively. It has a 99° scan angle with 56 scan steps having a scan plus retrace time of 6.4 sec, and has an earth coverage of 1127 km swath and 20.3 km (1.4° FOV field).

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Tiros-N
A. J. Cervenka, NASA HQ, EB-8

INSTRUMENT: Microwave Sounding Unit (MSU) EI-12

STATUS: Approved

CARRIER: NOAA-A through G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 30.0

Mass (kg): 19.1

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To determine radiances needed to calculate temperature and humidity profiles of the atmosphere from the planetary surface into the stratosphere. The MSU will have 4 channels operating in the 50 to 60 GHz oxygen band to obtain temperature profiles which are free of cloud interference.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

The four channels of the MSU have channel frequencies of 50.3, 53.74, 54.96, and 57.95 GHz with corresponding wavelengths of 6.0, 5.6, 5.5, and 5.2 mm, respectively.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Execution Phase Project Plan for Tiros-N and NOAA-A through G Operational Follow-On Satellites (7)
A. J. Cervenka, EB-8

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INSTRUMENT: Stratospheric Sounding Unit (SSU) EI-13

STATUS: Approved

CARRIER: NOAA-A through G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 17.5

Mass (kg): 15.9

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To determine radiances needed to calculate temperature and humidity profiles of the atmosphere from the planetary surface into the stratosphere. The SSU will have 3 channels, operating at 14.97 µm using selective absorption by passing the incoming radiation through three pressure modulated cells containing CO_2.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Each of the three channels (channels 15, 16, and 17) has a wavenumber of 668 cm^{-1}.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Execution Phase Project Plan for Tiros-N and NOAA-A through G Operational Follow-On Satellites (7)
A. J. Cervenka, EB-8

INSTRUMENT: Solar Backscatter Ultraviolet Spectrometer (SBUV) EI-14

STATUS: Approved

CARRIER: NOAA-F through G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.078 m^3

Power Requirement (We): 7 (step scan)
11 (continuous scan)

Mass (kg): 20

Data Rate (kbps): 0.082 (step scan)
0.270 (continuous scan)

PRINCIPAL PURPOSE AND FEATURES: To increase our knowledge of climatic processes, to begin an extensive ozone monitoring effort, and to develop techniques for short-term predictions--from a few months to a few years--for guiding government policy.

The SBUV determines the vertical ozone distribution by measuring the backscattered ultraviolet solar energy in the satellite nadir direction at 12 wavelengths in the ozone absorption band. The principle of operation is based on the accurate measurement of the backscattered solar energy (albedo) in the ultraviolet, between approximately 2500 and 3400 Angstroms. The 12 wavelengths of interest are positioned on the edge of the ozone absorption band. The shorter wavelengths are more sensitive to ozone high in the stratosphere, and the longer wavelengths are most sensitive to ozone low in the stratosphere. By mathematical inversion, it is possible to calculate the concentration of ozone as a function of altitude through the thickness of the stratosphere. The SBUV instrument is a double Ebert-Fastie spectrophotometer. The measurements at the 12 wavelengths are accomplished by a stepped-position grating in the double monochromator. When a diffuser plate is deployed to reflect light directly from the sun, the solar ultraviolet spectrum between 1600 and 4000 Angstroms can be measured. Operating the same monochromator in a continuous scan mode provides a detailed spectrum, either of the sun or the albedo radiation from the earth. The wavelengths are repeatable and known to within 0.2 Angstrom.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Wavelengths in the 1600-4000 Å ranges are measured to determine ozone distribution.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Solar Backscatter Ultraviolet Spectrometer (SBUV), An Operational Ozone Sounding Unit for the TIROS-N Spacecraft.
J. Lehman, NASA HQ, EBC-8; R. Seals, NASA HQ, EBT-8

INSTRUMENT: Ultraviolet Ozone Experiment EI-15

STATUS: Approved

CARRIER: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.35 × 0.13 × 0.10

Power Requirement (We): 2

Mass (kg): 2.72

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To monitor absorption of ultraviolet light by ozone. One band monitors absorption of ultraviolet light while another band serves as a reference for comparison.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Absorption at limb by ozone.

ASSOCIATED RANGES AND/OR RESOLUTION:

246-310 nm, 271-335 nm, 30 Å line half power width; 10 Å per step.

COMMENTS:

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8

INSTRUMENT: 1.27 μm Airglow Sensor EI-16

STATUS: Approved

CARRIER: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.35 × 0.13 × 0.10

Power Requirement (We): 5

Mass (kg): 2.72

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To measure products of ozone photo-dissociation.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Measures radiance due to O_2 ($^1\Delta g$), O_2 ($^1\Sigma g$), and OH.

ASSOCIATED RANGES AND/OR RESOLUTION:

0.7-1.4 μm, 1.2-2.4 μm, 70 Å line half power width, 27 Å per step.

COMMENTS:

Lead sulfide detector

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8.

INSTRUMENT: Visible Nitrogen Dioxide Experiment EI-17

STATUS: Approved

CARRIER: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.35 × 0.13 × 0.10

Power Requirement (We): 5

Mass (kg): 2.72

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To observe NO_2 absorption lines.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Radiance in 20-40 km limb region

ASSOCIATED RANGES AND/OR RESOLUTION:

520-770 nm, 5 Å per step; 325-450 nm, 10 Å per step, 10.6 Å line half power width.

COMMENTS:

Silicon photodiode detector

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8.

INSTRUMENT: Four-Channel Infrared Sensor EI-18

STATUS: Approved

CARRIER: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.60 × 0.25 (diam)

Power Requirement (We): 10

Mass (kg): 9.07

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To use 15 μm band to determine temperature/pressure as manifest by CO_2 line radiance, to observe 9.6 μm band emission, and to observe 6.3 μm H_2O emission.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Limb radiance.

ASSOCIATED RANGES AND/OR RESOLUTION:

17.2-13.2 μm, 15.7-14.7 μm, 10.6-8.6 μm, 7.2-6.1 μm.

COMMENTS:

HgCdTe detector

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8

INSTRUMENT: Solar Ultraviolet Monitor EI-19

STATUS: Approved **CARRIER**: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.35 × 0.13 × 0.11

Power Requirement (We): 2

Mass (kg): 2.95

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To monitor the suspected variability of ultraviolet flux.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Direct solar flux in ultraviolet range.

ASSOCIATED RANGES AND/OR RESOLUTION:

220-310 nm, 160-250 nm, 14 Å line half power width, 14 Å per step

COMMENTS:

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8

INSTRUMENT: Proton Alarm EI-20

STATUS: Approved

CARRIER: Solar Mesosphere Explorer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.05 × 0.05 (dia)

Power Requirement (We): 0.5

Mass (kg): 0.23

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Integrated solar proton flux from 30 to 500 MeV.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Project Plan for Solar Mesosphere Explorer 1981 Mission, JPL 629-1, September 1978.
S. Tilford, NASA HQ, EBT-8

INSTRUMENT: Vertical Temperature Profile Radiometer EI-21

STATUS: Approved **CARRIER:** NOAA-A

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.61 × 0.31 × 0.31 **Power Requirement (We):** 25, 5 (standby)

Mass (kg): 18.1 **Data Rate (kbps):** 0.24

PRINCIPAL PURPOSE AND FEATURES:

To measure the vertical profile of the atmospheric temperature and humidity and distribution of CO_2. Consists of filter spectrometer radiometer (eight bands, 11-19 μm), telescope (2.6 in. dia, f/3), detector, and image motion compensator.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

NER: 2.5×10^{-8} W/cm^2 sr cm^{-1}

Most spectral bands are 15 cm^{-1} wide, except 3 cm^{-1} wide near 15 μm.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

The radiometer is a pyroelectric sensor operating near ambient temperatures.

SOURCE/CONTACT: Barnes Engineering, Final Engineering Report: Part I, #2047-TR-60. Barnes Engineering, Description of Operation of VTPR, #2047-DER-04B1069. Andrew W. McCulloch, GSFC, 301/344-8079.
J. Theon, NASA HQ, EBC-8

INSTRUMENT: Advanced Very High Resolution Radiometer (AVHRR) EI-22

STATUS: Approved

CARRIER: NOAA A-G

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.27 × 0.37 × 0.79 m

Power Requirement (We): 29

Mass (kg): 30

Data Rate (kbps): 750

PRINCIPAL PURPOSE AND FEATURES:

To measure sea surface temperature from the space environment. AVHRR has 3 IR channels, a swath width of 1500 km, and a design life of 2 years. Accomplishes spectral separation by beam splitters.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Temperature range
175-320 K (10.8, 12.0 μm)
240-320 K (3.24 μm)
Accuracy: ±1 K
Resolution: 4 km

ASSOCIATED RANGES AND/OR RESOLUTION:

Channels	1	2	3
Center wavelength (μm)	3.74	10.8	12.0
Bandwidth (μm)	0.38	1.0	1.0

COMMENTS:

IR Detector materials
InSb, HgCdTe
Noise equivalent
ΔT: 0.12 K at 300 K
Aperture size: 20 cm
Focal length: 25 cm

IFOV: 1.3 mrad
Scan frequency: 360 rpm
Scan width: ±40°

SOURCE/CONTACT: A. J. Cervenka, EB-8
National Oceanic Satellite System, joint effort by NASA, NOAA, DoD, 23 March 1979

INSTRUMENT: Dual Frequency Scatterometer EI-23

STATUS: Planned **CARRIER:** Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 4.6 x 1.5 x 0.3 **Power Requirement (WE):** 200

Mass (kg): 150 **Data Rate (kbps):** < 10

PRINCIPAL PURPOSE AND FEATURES:

Microwave scatterometry of oceans. Up to 3, 4.6 × 0.3 m phased array antennas.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Microwave radar scattering from ocean surface, principally ocean wave spectra.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

There exists considerable controversy over the theoretical aspects of this instrument. Will not be pursued until these are resolved. Instrument is conceptual at this time.

SOURCE/CONTACT: J. Johnson, LaRC, (804) 827-3631
W. Townsend, NASA HQ, EBC-8
MSFC Draft of Platform Payloads, 10 January 1980

INSTRUMENT: Dual Antenna Multibeam Altimeter EI-24

STATUS: Planned **CARRIER**: Shuttle Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 425

Mass (kg): 200

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Provides ocean surface topography. A possible simplification of two Seasat class altimeters.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

The entire system consists of 2 antennas, 2 m diameter, 1 m deep, with 11 m separation having a beamwidth of 0.76°. Conceptual at this time.

SOURCE/CONTACT: W. Townsend, NASA HQ, EBC-8
MSFC Draft of Platform Payloads, 10 January 1980

INSTRUMENT: Large Antenna Multifrequency Microwave Radiometer (LAMMR) EI-25

STATUS: Planned

CARRIER: NOSS

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 4 dia antenna

Power Requirement (We): 235

Mass (kg): 220

Data Rate (kbps): 50

PRINCIPAL PURPOSE AND FEATURES: The LAMMR is a multichannel, dual linear polarization microwave radiometer system which operates in five frequency bands from 4.3 to 37 GHz. From a 700 km orbit, the swath width is 1350 km, and the ground resolution varies from 36 km at 4.5 GHz to 7 km at 37 GHz, using a 4 m diameter aperture antenna which rotates 360° continuously at approximately 1 revolution per second. The passive system is operated during 120° (forward direction) of the 360° of rotation to collect the primary passive channel data. During the remaining 240°, calibration will occur for approximately 30°.

An offset parabolic reflector was chosen for the antenna because of its ability to operate over wide frequency ranges with high beam efficiency and low system RF losses. The cassegrain feed approach for 4.3 to 37 GHz, and the prime-focus feed approach for 1.4 GHz has tentatively been selected over a total prime-focus approach because of its more compact mechanical configuration which will tend to minimize the anticipated problems in dynamically and statically balancing this sensor at the 1 rps scan rate.

The radiometer electronics subsystem design proposes to use total power radiometers, which are calibrated once a second using ambient loads and cold sky horns on all channels.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Sea Ice
- Concentration
  - Accuracy: 2%
  - Resolution: 25 km
- Type
  - Accuracy: 10%
  - Resolution: 1 km

Surface melting
- Resolution: 25 km

Sea surface temperature
- Accuracy: 0.2 K
- Resolution: 1 km

Wind velocity vector
- Accuracy: 2m/s (10° direction)
- Resolution: 25° azimuth

Ice Sheet
- Accumulation rate
  - Accuracy: 10%

Snow Cover
- % of cover
  - Accuracy: 5%

ASSOCIATED RANGES AND/OR RESOLUTION

Operating frequencies 4.3 to 37 GHz.

COMMENTS:

The analog data from the radiometers will be digitized to 12 bit accuracy on the rotating structure to form a digital bit stream which is passed through the slip rings to the downlink telemetry system. An on-board processor will be used to serve three functions: the first will be to control the operation of the radiometers and to monitor the system performance with diagnostic checkouts; the second will be to format the data into a digital bit stream. The third will be to calibrate and convert the radiometric temperatures into geophysical units for near real time lower-resolution transmission to the ground.

SOURCE/CONTACT:

D. Broome, NASA HQ, EBC-8
Preliminary Execution Phase Project Plan for Ice Experiment, Goddard Space Flight Center

INSTRUMENT: Scatterometer (SCAT) EI-26

STATUS: Planned

CARRIER: National Ocean Satellite System (NOSS)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.7 m^3

Power Requirement (We): 309

Mass (kg): 224

Data Rate (kbps): 4

PRINCIPAL PURPOSE AND FEATURES: SCAT is an active radar scatterometer, the design of which is based upon Seasat SASS. It will operate at a frequency of 14.6 GHz and will have a 1000 km swath width. The functional objective of SCAT is to measure wind speed and wind direction (on earth) from a space environment. This improved version of the Seasat scatterometer will, in theory, have six 3-m stick array antennas, but in practice may have anywhere from 4 to 8 antennas depending upon which option is chosen.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Wind Speed	Wind Direction
Accuracy: 2 m/sec	Accuracy: 10°
Range: 0-50 m/sec	Range: 0-360°
Precision: 0.5 m/sec	Precision: 5°
Horizontal resolution: 25 km	Horizontal resolution: 50 km

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

D. Broome, NASA HQ, EBC-8.
National Oceanic Satellite System, joint effort by NASA, NOAA, DoD, 23 March 1979.

INSTRUMENT: Scanning Multichannel Microwave Radiometer (SMMR) EI-27

STATUS: Planned

CARRIER: ND

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): $15\ m^3$

Power Requirement (We): 150

Mass (kg): 350

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To measure wind speed, ice coverage, ice age, atmospheric liquid water, atmospheric water vapor, precipitation over land and over water from the space environment by use of total power radiometers. Soil moisture and salinity could also be measured with the addition of an L-band channel. This is an improved version based on Seasat-1. Uses a 4 m rotating parabolic dish antenna as opposed to the 0.8 m antenna of Seasat-1 and has a swath width of 1350 km as opposed to only 600 km on Seasat-1.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Wind Speed
- Precision: 2 m/sec
- Accuracy: 2 m/sec
- Resolution: 15 km

Ice Coverage
- Precision: 1%
- Resolution: 7 km

Ice Age
- Precision: ±10%
- Resolution: 3.5 km

Atmospheric Liquid Water
- Precision: $3\ mg/cm^2$
- Resolution: 9 km

Atmospheric Water Vapor
- Precision: $150\ mg/cm^2$
- Resolution: 9 km

Precipitation Over Land
- Resolution: 9 km

Precipitation Over Water
- Precision: ±1 octave
- Resolution: 9 km

ASSOCIATED RANGES AND/OR RESOLUTION:

Channels: 1; 2; 3; 4; 5; 6
Frequency (GHz): 4.3; 10.65; 18.7; 21; 36.5; 91
Beamwidth (deg): 1.22; 0.49; 0.28; 0.25; 0.25; 0.25
Surface resolution (km): 22 × 34; 9 × 14; 5 × 7.8; 4.5 × 7; 4.5 × 7; 4.5 × 7
Integration time (msec): 7.7; 3.1; 1.8; 1.6; 1.6; 1.6
Noise temperature (K): 400; 500; 400; 400; 800; 1200
Predetection bandwidth (MHz): 200; 100; 100; 100; 700; 1000
Sensitivity (K): 0.167; 0.86; 1.3; 1.43; 0.94; 0.94

COMMENTS:

Lifetime: 3 yr

SOURCE/CONTACT: D. Broome, NASA HQ, EBC-8
National Oceanic Satellite System; joint effort by NASA, NOAA, DoD, 23 March 1979

INSTRUMENT: Radar Altimeter (ALT) EI-28

STATUS: Planned **CARRIER**: TOPEX

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): **Power Requirement (We)**:

Mass (kg): **Data Rate (kbps)**:

PRINCIPAL PURPOSE AND FEATURES:

A possible enhancement of a Seasat altimeter to measure surface topography, which when utilized with vapor density and marine geoid will provide global ocean circulation information.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Requirements for sea state height measurements to a precision of 1-2 cm. Possible multibeam option. Very conceptual in nature at this time.

SOURCE/CONTACT:

W. Townsend, NASA HQ, EBC-8

INSTRUMENT: Coastal Zone Color Scanner (CZCS) EI-29

STATUS: Planned

CARRIER: National Oceanic Satellite System

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Mass (kg): 40

Power Requirement (We): 50

Data Rate (kbps): 1.8 Mbps

PRINCIPAL PURPOSE AND FEATURES: The CZCS is designed to emphasize the management of ocean resources. It provides three channels for chlorophyll determination, one for Gelbstoffe (a yellowish conglomeration of detritus related to nutrients and microscopic organisms), one for surface vegetation, a reference IR temperature channel to indicate current boundaries and upwelling, and two channels in the near-IR range to achieve additional accuracy by correcting the imagery for the effects of atmospheric turbidity.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

Channels: 0.4, 0.44, 0.52, 0.56 0.64. 0.685, 0.750, 0.88 μm
Bandwidth: 20 nm
Detectors: silicon, photodiode
Aperture size: 17.78 cm

Focal length: 71.12 cm
IFOV: 0.865 x 0.865 mrad
Scan rate: 480 rpm
Scan width: ±40%

COMMENTS:

Colorimetry contributes significantly to the management of the ocean's biological resources, ocean pollution control, and ocean dynamics relative to sediment transport.

SOURCE/CONTACT: D. Broome, NASA HQ, Code EBC-8
National Oceanic Satellite System; joint effort by NASA, NOAA, DoD, 23 March 1979

INSTRUMENT: Solar UV Spectrometer EI-30

STATUS: Planned

CARRIER: Upper Atmosphere
Research Satellite (UARS)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Study the radiation, chemistry, and dynamics of the upper atmosphere at low, mid, and moderately high altitude and the coupling between these properties to determine the seasonal correlations.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

All UARS instruments are conceptual in nature only. The actual instrument complement is under active selection at this time. The "real" instrument complement should be available approximately August 1980.

SOURCE/CONTACT: R. Seals, NASA HQ, EBT-8
Upper Atmosphere Research Satellite Program, Final Report of the Science Working Group, JPL Document No. 78-54, July 1978

INSTRUMENT: UARS Instruments (EI-31 through EI-41)

STATUS: Planned

CARRIER: Upper Atmosphere Research
Satellite (UARS
Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Study the radiation, chemistry, and dynamics of the upper atmosphere at low, mid, and moderately high altitude and the coupling between these properties to determine the seasonal correlations.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

EI-31	Doppler Interferometer
EI-32	Modulated Gas Cell Radiometer
EI-33	Filter Radiometer
EI-34	Nadir Emission Radiometer
EI-35	Emission Radiometer
EI-36	Occulation Radiometer
EI-37	UV Airglow Emission Spectrometer
EI-38	1.27 μm Emission Spectrometer
EI-39	Far IR Spectrometer
EI-40	Laser Heterodyne Radiometer
EI-41	Microwave Limb Sounder

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

All UARS instruments are conceptual in nature only. The actual instrument complement is under active selection at this time. The "real" instrument complement should be available approximately August 1980.

SOURCE/CONTACT:

R. Seals, NASA HQ, EBT-8
Upper Atmosphere Research Satellite Program, Final Report of the Science Working Group, JPL Document No. 78-54, July 1978

INSTRUMENT: LIDAR

EI-42

STATUS: Planned

CARRIER: Multiuse Lidar Systems

PHYSICAL AND GENERAL PROPERTIES:

Overall dimension (m): 4.35 × 2.9 × 4.1
Total mass (kg): 1990
  Receiver telescope: 693
  Laser module: 170
  CW-CO_2 laser: 2
  Pulsed CO_2 laser: 210
  Detector subsystem: 64
  Power conditioning: 139
Average power consumed (kWe): 2.35-4.23
Peak power consumed (kWe): 4.23

Power requirement (We)
  Telescope receiver: 31-30
  Laser Module: 1870
  CW-CO_2 module: 200
  Pulsed CO_2 module: 3750
  Detector subsystem: 405
  Power conditioning: 20
Data rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Design, develop, fabricate, assemble, test, and deliver a Shuttle-borne atmospheric lidar multiuser instrument system capable of performing a wide range of scientific investigations through evolutionary growth, responsive to atmospheric science, weather and climate, and environmental quality needs.

ASSOCIATED RANGES AND/OR RESOLUTION:

See attached pages.

COMMENTS:

A conceptual instrument system, its definition and features will change as the status changes.

SOURCE/CONTACT:

R. Seals, NASA HQ, EBT-8; Jack Harris, LaRC, 804/827-3951

Atmospheric Lidar Multiusers Experiment System Definition Study, Final Report GE for NASA-LRC, Oct. 1979, NASI-15476

Shuttle Atmospheric Lidar Research Program, Final Report of Atmospheric Lidar Working Group, NASA SP-533, 1979

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
LIDAR			
Measure Cloud Top Height	Measure cloud top heights with lidar while co-aligned passive sensors view the same area.	530/1060 nm	Receiver Telescope Classical Cassegrain 1.2 m dia, F/2.0 } Primary 16 cm dia, F/14 } Secondary Stops: 0.1-6 mrad Coating: Al + MgF_2 Nd: YAG Laser λ: 532 nm ± 100 pm 355 nm ± 70 pm Energy: 700 mJ, 200 mJ Pulse rate: 10 Hz Dye Laser λ: 215-940 nm ± 0.5 pm Energy: 5-200 mJ Life: 10^6 pulses CW-CO_2 Laser λ: 10.6 μm Frequency Stability: ±5 MHz Life: 250 hr Pulsed CO_2 Laser Energy: 10 J per pulse Pulse rate: 15 Hz λ: 9-11 μm Stability: ±5 MHz Pulse width: 200-10,000 ns Amplitude Stability: 0.01-0.1%
Profiling of Tropospheric Clouds and Aerosols	Measure the presence, geometrical profiles, and backscattering of the thin clouds and aerosols. Convert to optical thickness using models and 2λ backscatter information. Co-aligned Earth radiation budget sensor would measure flux and albedo changes; co-aligned passive temperature and humidity sensors would allow assessment of cloud and aerosol effects on passive profilers.	530/1060 nm	
Cirrus Ice/Water Discrimination	Two polarization components of the backscattered signal (for a linearly polarized transmitted signal) from cloud layers are used to discriminate between spherical water droplets and ice crystals in cirrus clouds.	530 nm	
Profiles of Noctilucent Clouds and Circumpolar Particulate Layers	Determine presence, structure, and density of noctilucent clouds and particulate layers near the Summer mesopause by elastic (Mie) backscatter to evaluate radiative effects of the layers and use them as tracers of atmospheric dynamics.	530/1060 nm	
Earth Surface Albedo Measurement	Measure surface reflectance at several wavelengths while Earth radiation budget sensors view the same area. This experiment could be coupled with others such as 1, 2, and 6, deriving surface reflectance from surface-return signal and attenuation corrections	530/1060 nm	

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Stratospheric Aerosol Backscatter Profiles	Measurement of stratospheric aerosol from orbital altitudes using particulate backscattering at wavelengths of 530 nm and 1060 nm in order to obtain global-scale information on their distribution.	530/1060 nm	**Detector Subsystem** Single PMT: λ_1: 215-300 nm λ_2: 455-540 nm λ_3: 720-940 nm Two PMT: (Requires photocathode cooling) λ_1: 440-530 nm λ_2: 1060 nm Two PMT with polarization separation λ_1: 530 nm Three PMT: λ_1: 280-290 nm λ_2: 500 nm Fabry-Perot Interferometer: λ_1: 530 nm λ_2: 589 nm 2 Far IR Cryogenic Heterodyne: λ_1: 9-11 μm
Alkali Atom Density Profiles	Determine altitude profiles of the free sodium atoms in the layer from 80 to 110 km by observation of sodium resonance fluorescence excited by a pulsed tunable dye laser.	589/671/770 nm	
Ionospheric Metal Ion Distributions	Use laser resonant scattering to obtain altitude profiles of Mg^+ density from 80 to 500 km to study ionospheric irregularities (which affect communications systems), lower thermospheric neutral wind patterns, and general ionospheric circulation patterns.	280 nm & Other Resonance Lines	
Water Vapor Profiles	Measure water-vapor profiles in the troposphere using the 720 or 820 nm bands of H_2O, or in the tropopause and lower stratosphere using the 940 nm band, with a differential absorption technique (DIAL).	Two Near 720 and 940 nm	
Atmospheric Species Measurements--IR Laser Ground and Cloud Returns	Measure concentrations of a variety of species such as O_3, H_2O, NH_3, the CF,s, CCl_4, C_2H_4, and C_2H_3Cl using CO_2 lasers; or CH_4, CO_2, N_2O, CO and HCl with other IR lasers (doubled CO_2, CO, etc.). Species total burdens in the troposphere and stratosphere and species profiles with 3 to 4 km vertical resolution would be obtained using reflection from the Earth's surface and from clouds.	Two in 9-11 μm Range	

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

LIDAR

EI-42

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Chemical Release Diagnostics	Use laser resonant scattering to measure motion, internal structure, and dissipation of artificial chemical releases (e.g., Na, Ba, and Ba^+) for diagnosis of ionospheric fields and dynamics.	Several in 400-600 nm Range	
Stratospheric Ozone Concentration Profiles	Measurement of stratospheric ozone concentration between 15 and 50 km using differential range absorption techniques at UV wavelengths in order to provide global-scale information on ozone vertical distribution.	265 nm to 300 nm	
Upper Atmospheric Trace Species Measurement Using Two Satellite Earth Occultation	Trace species having absorption bands in the 3.5 to 15.0 μm region are measured with high accuracy, day or night, by direct absorption of IR laser radiation transmitted between two satellites. Typical species include O_3, ClO, $ClONO_2$, H_2O, H_2O_2, the CFMs, C_2H_3Cl, C_2H_4, CCl_4, HNO_3, NH_3, etc.	Two in 9-11 μm Region or Scanning Laser	
Sodium Temperature and Winds	Doppler sensitive detection of the resonance backscattered signal from the Na layer near 90 km to determine the altitude of sodium, its temperature, and winds in the sodium layer.	589 nm	
Surface Pressure and Cloud Top Pressure and Height Measurement	Accurate measurement of atmospheric pressure at the Earth's surface and of pressure and altitude at cloud tops using surface and cloud returns of laser radiation tuned to the O_2 A-band absorption lines.	Two Near 760 nm	

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Vertical Profiles of Atmospheric Pressure	Height-resolved tropospheric pressure profiles will be measured using a differential absorption method employing larger spatial resolution elements than in experiment 15.	Two Near 760 nm	
Troposphere/Tropopause Temperature Profiles	Measure the (height-resolved) temperature profile in the troposphere or in the region of the tropopause with a DIAL technique.	Two Near 760 nm	
Altitude Distribution of Atmospheric Constituents IR DIAL	Tropospheric profiles of gases such as O_3, H_2O, NH_3, and C_2H_4, and stratospheric O_3 profiles, will be measured using differential absorption lidar (DIAL) based on scattering of CO_2 laser radiation pulses by atmospheric aerosols.	Two in 9-11 μm Range	
Measure Cloud Top Winds to 5 m/s	Measure the wind at the top of the clouds, during the day or night, with an uncertainty in the measurement of ±2 m/s by Doppler sensitive detection of cloud-top returns. Both incoherent detection of Nd laser radiation and coherent detection of CO_2 laser radiation are considered.	350 nm - 110 nm + 9-11 μm	
Aerosol Winds Between Ground and 30 km Altitude	Measure the height-resolved wind profile between ground and 30-km altitude by Doppler sensitive detection of molecular and aerosol-scattered returns at either Nd or CO_2 laser wavelengths.	0.35 to 11 μm	
OH Density Profiles 35-100 km	Determine the density of OH in the upper atmosphere by observing remote fluorescence from OH excited by a tuned laser with wavelength in the range 280 to 310 nm.	~300 nm	

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Simultaneous Measurement of Metallic Atom, Ion, and Dioxide Profiles	Use multiwavelength resonant scattering to obtain simultaneous altitude profiles of Mg, Mg$^+$, and MgO densities to provide information on the gross features of upper and lower thermospheric circulation.	280, 285, 500 nm (Three Simultaneous)	
Tropospheric NO_2 Concentration Profile--Total Burden of NO_2	Measure tropospheric NO_2 density between 0 and 4 km and total NO_2 column using DIAL techniques in the 450 nm spectral region.	442 + 448 nm (Two Simultaneous)	
Stratospheric Aerosol Composition	Identify the chemical composition of stratospheric aerosols using pattern-recognition techniques with multiwavelength (infrared) aerosol backscattering (DISC differential scattering).	9-11 μm	
NO Density Profiles Between 70 and 150 km Altitude	Altitude profiles of NO will be measured by resonance scattering or fluorescence, using a tunable laser which is frequency-doubled into the NO γ-bands or suitable excimer lasers that may be developed in the future.	215 to 277 nm	
Abundance and Vertical Profiles of Atomic Oxygen	Altitude profiles of O will be measured by two-photon fluorescence spectroscopy, using very short pulses of tunable radiation at 225.6 nm.	225 nm Transmit, 844.9 Receive	

INSTRUMENT: Radar Altimeter (ALT) EI-43

STATUS: Planned

CARRIER: National Oceanic Satellite System (NOSS)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1-m antenna

Power Requirement (We): 168

Mass (kg): 164

Data Rate (kbps): 8.5

PRINCIPAL PURPOSE AND FEATURES: To measure altitude, winds, sea state, ice coverage, sheet ice, and to determine iceberg locations from the space environment. This altimeter is a low risk improvement of the Seasat altimeter. The modification provides complete sensor redundancy for improved reliability and ground control of selectable sensor operation modes. Control of the sensor operation modes will provide an improved capability of measuring significant wave heights at high sea states (to 25 m) and a capability of range gating the signal return for determination of precipitation rates along the subsatellite track.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Altitude
- Precision: 10 cm
- Resolution: 1.6-12 km

Winds
- Accuracy: <20%
- Resolution: <15 km

Sea State
- Precision: 0.5 m
- Accuracy: 5 m ± 50 cm
- Resolution: <10 km

Ice
- Cover: 10%
- Resolution: <15 km

Sheet Ice
- Changes: 0.3 m

Berg Location
- Accuracy: ±1 km
- Resolution: 0.2 km

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

W. Townsend, NASA HQ, EBC-8
National Oceanic Satellite System, joint effort by NASA, NOAA, DoD, 23 March 1979.

INSTRUMENT: 2-Channel Microwave Radiometer EI-44

STATUS: Planned **CARRIER**: TOPEX

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To permit removal of atmospheric effects on propogation of radar altimeter signal for TOPEX mission.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This instrument represents no new technology.

SOURCE/CONTACT: W. Townsend, NASA HQ, EBC-8

INSTRUMENT: Cryogenic Limb Scanning Interferometer Radiometer EI-45

STATUS: Planned

CARRIER: Cryogenic Limb Scanning Interferometer Radiometer (CLIR)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.8 (dia) × 3 (L)

Power Requirement (We): 120

Mass (kg): 480 typical

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The cryogenic limb scanning interferometer radiometer (CLIR) is an instrument assembly combining a Michelson interferometer spectrometer and multichannel radiometer. Both instruments share the same narrow field of view (4 arc min) through a baffled off-axis spherical telescope of low scatter and high off-axis rejection. Both instruments can operate simultaneously. The cooling of the telescope, instruments, and optics will limit the noise level from the instrument to the detector-preamplifier noise level. Hence quantum fluctuations in the source and/or background radiation become the limiting factor to attaining near maximum sensitivity. The basic mode of operation will be limb scanning with an altitude resolution of 2 km from Shuttle orbit.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

See following page.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Key technology requirements are for long-term cryogenic operation. This particular instrument is currently conceptual at this stage and its features will change as its status changes.

SOURCE/CONTACT:

R. Seals, NASA HQ, EBT-8
Cryogenic Limb Scanning Interferometer and Radiometer, Reports of the Spectroscopy Facility Definition Team

INSTRUMENT: Cryogenic Limb Scanning Interferometer Radiometer (Cont.) EI-45

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

Telescope aperture size:	25 cm diameter, off-axis spherical
Interferometer aperture size	5 cm diameter
FOV, total instrument:	3.2 (vert) × 6.2 (horiz) mrad
IFOV, radiometer and interferometer:	1.0 (vert) × 2.0 (horiz) mrad
Resolution:	
Radiometer (vertical at limb):	2 km tangent altitude
Interferometer (spectral):	1.0 to 0.1 cm^{-1}
Scan time:	1 sec to 10 sec
Telescope off-axis rejection:	NER = 10^{-10} at 1° off-axis
Pointing stability:	0.5 arc min
Cryogen:	Super critical helium
Cryogen weight:	70 kg (30 day mission)
Operating temperatures:	8.5 to 12 K (detectors) 30 K (optics) 115 K (baffles)
Sensitivity, NESR inferferometer:	10^{-12} $W/cm^2/sr/cm^{-1}$ at 400 cm^{-1} 10^{-10} $W/cm^2/sr/cm^{-1}$ at 4000 cm^{-1}
Sensitivity, NER radiometer channels:	1.9×10^{-11} $W/cm^2/sr$ 9.5×10^{-13} $W/cm^2/sr$; 25 channels
Dynamic range, interferometer:	10^5
Spectral coverage:	
Radiometer (25 channels):	1.5 μm to 25 μm Provision to add 4 window channels and focal plane, 25 μm to 100 μm range
Interferometer:	2.5 μm to 25 μm

INSTRUMENT: Spaceborne Meteorological Radar EI-46

STATUS: Planned **CARRIER**: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Information unavailable at this time.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

S. Tilford, NASA HQ, EBT-8, STS Payload Planning Data, Vol. I, Teledyne Brown Engineering, P179-MSCF-2327, April 1979

INSTRUMENT: Lidar Pressure and Temperature Sensor EI-47

STATUS: Planned **CARRIER:** Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): **Power Requirement (We):**

Mass (kg): **Data Rate (kbps):**

PRINCIPAL PURPOSE AND FEATURES:

Information unavailable at this time.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT: J. Theon, NASA HQ, EBC-8; C. L. Korb, GSFC; STS Payload Planning Data - Vol. I, Teledyne Brown Engineering, P179-MSFC-2327, April 1979

INSTRUMENT: Microwave Pressure Sounder

STATUS: Planned

CARRIER: Shuttle (tests), meteorological satellites

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): <0.5 m^3

Power Requirement (We): <100

Mass (kg): 50

Data Rate (kbps): 1 (max)

PRINCIPAL PURPOSE AND FEATURES:

To remote measure atmospheric pressure at the surface of the earth. Shuttle tests will be used to prove the concept prior to operational use on meteorological satellites. As presently envisaged the package will have a pair of antennas, each with area of about 0.2 m^2, a RF subsystem, and an electronics subsystem of total volume of 0.1 m^3

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Two system designs are conceived for this--a fixed frequency design and a swept frequency design . These are shown on the following page.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

The features of the instrument are conceptual and may change with its status.

SOURCE/CONTACT:

Dr. Dennis A. Flower, JPL, 213/354-4151
J. Theon, NASA HQ, EBC-8
A Microwave Pressure Sounder, D. A. Flower, G. E. Peckham, JPL 78-68, 1 August 1978
STS Payload Planning Data, Volume II, OSTA Payload Planning Data, Teledyne Brown Engineering P179-MSFC-2327

INSTRUMENT : Microwave Pressure Sounder

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

Fixed Frequency System Design Parameters			
Operating Frequencies	29.2555	44.80	67.51
(GHz)	36.5555	52.80	73.01
Transmitter power	2 W		
Feed efficiencies	0.85		
Antenna dimensions	20 × 150 cm		
Integration time	12 sec		
Duty cycle	0.166		
Satellite altitude	500	800 km	
Satellite speed	7.61	7.45 km sec^{-1}	
Receiver bandwidth	76.1	74.5 kHz	
Pulse length	3.33	5.33 msec	

Swept Frequency System Design Parameters			
Operating Frequencies	29.2555	44.80	67.51
(GHz)	36.5555	52.80	73.01
Transmitter power	2 W		
Feed efficiencies	0.85		
Antenna dimensions	28 × 150 cm		
Integration time	12 sec		
Duty cycle	0.166		
Factor	12		
Satellite altitude	500	800 km	
Satellite speed	7.61	7.45 km sec^{-1}	
Receiver bandwidth	76.1	74.5 kHz	
Pulse length	3.33	5.33 msec	
Sweep repetition time	18.4	18.8 μsec	

Total Sweep (MHz) and Sweep Rate (MHz μsec^{-1}) for A500 km, B800 km							
	Channel	1	2	3	4	5	6
A.	Total sweep	14.100	22.00	33.00	45.90	75.00	87.80
	Sweep rate	0.766	1.20	1.80	2.49	4.08	4.77
B.	Total sweep	8.810	13.700	20.60	28.70	46.90	54.80
	Sweep rate	0.469	0.732	1.10	1.53	2.50	2.92

INSTRUMENT: Standard Ozone Sounding Unit (SOSU) EI-49

STATUS: Planned

CARRIER: Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.078 m^3

Power Requirement (We): 10, 4 (standby), 24 (peak)

Mass (kg): 20

Data Rate (kbps): 0.269 (max)

PRINCIPAL PURPOSE AND FEATURES:

Provide periodic calibration of ozone monitors on free-flyers. Provide ozone measurements to supplement free-flyers as required. Measure absolute solar spectral irradiance 160-400 nm wavelengths. Provide continuity of measurements and calibration between free-flyers. Provides quarterly measurements of solar spectral irradiance.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Filter/grating spectrometer has spectral range of 160-400 nm either continuous scan or step scan in 12 steps (255-340 nm), with a spectral resolution of 1 nm. Measures solar irradiance and backscattered UV to determine atmospheric ozone.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This conceptual instrument is not under any consideration at this time. Its purpose, features, and so forth are those of the solar backscatter ultraviolet spectrometer (SBUV) for NOAA F and G.

SOURCE/CONTACT:

Standard Ozone Sounding Unit Proposed for First Spacelab Mission, GSFC, June 1976.
R. J. Pinamonti, GSFC, 301/344-7624.
R. Seals, NASA HQ, EBT-8

INSTRUMENT: Laser Absorption Spectrometer (LAS) EI-50

STATUS: Planned **CARRIER**: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 1500

Mass (kg): 59

Data Rate (kbps): 0.5

PRINCIPAL PURPOSE AND FEATURES:

To measure atmospheric trace gases (O_3, NH_3, H_2O, ethylene) in troposphere and stratosphere. Equipped with two flowing gas CO_2 lasers, 1.0-m class telescope, and pointing system.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Two 10-25 W lasers operating in spectral range of 9-11 μm.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This particular conceptual instrument is a subset of the Multiuse Lidar Systems (MULS) experiments.

SOURCE/CONTACT: R. Manzies, JPL, 213/354-3787; R. Seals, NASA HQ, EBT-8
STS Payload Planning Data, Volume II-OSTA Payload Planning Data, April 1979
Teledyne Brown Engineering, P179-MSFC-2327

INSTRUMENT: Correlation Interferometry for Measurement of Atmospheric Trace Species (CIMATS)

EI-51

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.15 m^3

Power Requirement (We): 160, 100 (standby)

Mass (kg): 100

Data Rate (kbps): 3.0 (max)

PRINCIPAL PURPOSE AND FEATURES:

Measurement of atmospheric trace species and pollutants for the determination of man-made and natural sources and sink mechanisms. Approach is to obtain tropospheric column burdens by nadir viewing or stratospheric profiles by solar/limb occultation. Species measured include CO, CH_4, N_2O, NH_3, SO_2.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION: Sensor is a field-widened, partially scanned Michelson interferometer. Makes one measurement per second, simultaneously in each of two IR bands, 2-3 μm, and 4-9 μm. Specific measurement wavelengths within each band are selected by optical filters on filter wheel. Measured interferograms are analyzed in ground-based computer to determine species concentrations. Experiment includes radiometer for cloud cover determination. AAFE development is complete. Detector operating temperatures 195 and 77 K. Can view nadir or solar occultation depending on application.

COMMENTS:

SOURCE/CONTACT: P. Lebel, LaRC, 804/827-3761; E. Prior, NASA HQ, EBT-8; STS Planning Data, Volume II, OSTA Payload Planning Data, April 1979, Teledyne Brown Engineering, P179-MSFC-2327

INSTRUMENT: Temperature Humidity Infrared Radiometer (THIR) EI-52

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.018 m^3

Mass (kg): 9.1

Power Requirement (We): 7.5, 1.8 (standby)

Data Rate (kbps): 0.360 (max)

PRINCIPAL PURPOSE AND FEATURES:

THIR is a 2-channel high-resolution scanning radiometer designed to measure the earth's terrestrial, cloud, and atmospheric radiation. The 6.7 µm channel with 21 mrad IFOV measures absolute radiation temperature of atmospheric humidity; and the 11.5 µm channel with 7 mrad IFOV measures absolute radiation temperature of the earth and its cloud cover.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

THIR monitors earth radiation in two IR bands. Total scan angle is 150° cross track. Requires view beyond limb on each scan for calibration. Continuous rotation scan mirror is required to operate during ascent to protect bearings. Only requires on/off control. In use on NIMBUS, existing instrument supply is exhausted. 6.7 µm channel measures moisture content of upper troposphere and stratosphere. 11.5 µm channel images cloud cover and temperature of cloud tops, land, and sea. Filter spectrometer with rotating (48 rpm) scanning mirror. Telescope 0.125 m diameter, f/3.38. Detectors operate at ambient (293 K) temperature.

ASSOCIATED RANGES AND/OR RESOLUTION:

NE ΔT: 0.3 K at 300 K

COMMENTS:

The device is a bolometer and is similar to ITOS and Nimbus instruments.

SOURCE/CONTACT:

Nimbus E/F, THIR Data Book, Volume I, December 1972, SBRC.
Thomas Anderson, GSFC, 301/344-5198
J. Theon, NASA HQ, EBC-8
Andrew McCulloch, GSFC

INSTRUMENT: Atmospheric Emission Photometric Imaging (AEPI) EI-53

STATUS: Planned **CARRIER:** Spacelab 1

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):		**Power Requirement (We):**	106, 58 (standby) 296 (peak)
Mass (kg):	135	**Data Rate (kbps):**	1

PRINCIPAL PURPOSE AND FEATURES: The objective is to produce images of various atmospheric emissions to: (1) investigate ionospheric transport processes; (2) observe induced emission from artificial particle injection; (3) measure electron impact cross sections of atmospheric species; (4) measure small particle contamination in the vicinity of the Orbiter; (5) make pilot studies of natural aurora at high spectral and temporal resolutions and in the ultraviolet. Simultaneous operation of electron particle accelerator experiment is needed for some experiments.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Ionospheric Transport
Spectral range: 279.5-280.2 nm; 247.0 nm, 731.9 nm

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS: The equipment consists of a dual channel, low light level video system mounted on a stabilized, two-axis gimbal system for pointing and control with associated optics and data handling electronics. The mount will incorporate a modified Skylab star tracker. Filter wheels are used to isolate the emissions of interest. A dedicated experiment processor, control module, and video encoder are rack-mounted in the module. Payload specialist will operate the experiment. Video system will use the Orbiter TV monitor to monitor data. Design life is 14 flights over a 7-year period.

SOURCE/CONTACT: R. Seals, NASA HQ, EBT-8
Spacelab Mission 1 Experiment Descriptions, MSFC, NASA TM-78173, May 1978

INSTRUMENT: Advanced Meteorological Sounding Unit EI-54

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Information unavailable at this time.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

J. Theon, NASA HQ, EBC-8
James Shine, GSFC, 953.0, 344-6716

INSTRUMENT: Advanced Meteorological Temperature Sounder EI-55

STATUS: Planned **CARRIER**: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): $0.22\ m^3$

Power Requirement (We): ≤ 100 (pallet) ≤ 150 (module)

Mass (kg): 294

Data Rate (kbps): 2.8 (max)

PRINCIPAL PURPOSE AND FEATURES:

To develop an all-weather sounder for recovering atmospheric temperature and humidity profiles and day and night cloud cover in the presence of multiple cloud formations.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Measures temperature and humidity.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT: J. Theon, NASA HQ, EBC-8; L. Kaplan, J. Susskind, GSFC; STS Payload Planning Data, Vol II - OSTA Planning Data, Teledyne Brown Engineering, P179-MSFC-2327, April 1979

INSTRUMENT: High Resolution Doppler Imager EI-56

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.25

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

This instrument is a triple etalon Fabry-Perot interferometer which can view the earth's atmosphere through either of two imaging telescopes, one with high angular resolution for small scale imaging of features such as the stratosphere viewed on the horizon and a second low angular resolution channel which views larger angular regions such as the thermosphere or the troposphere in a direct viewing mode.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Spectral resolution: 0.02 cm^{-1}
Spectral stability: 2.5×10^{-4} cm^{-1}

Wide angle telescope	Narrow angle telescope
FOV: 6°	FOV: 1.5°
Pixel size: 0.4°	Pixel size: 0.1°
10^{-12} rejection at 45° cant	10^{-8} rejection at 45° cant

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Selected for development.

SOURCE/CONTACT: R. Arnold, NASA HQ, EB-8
High Resolution Doppler Imager, Part I: Technical Section, University of Michigan, November 1978

INSTRUMENT: High Resolution Solar Spectrometer EI-57
(also known as Solar and Terrestrial Atmospheres Spectrometer)

STATUS: Planned **CARRIER**: Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 3.67 × 0.44 × 0.85 **Power Requirement (We)**: 200

Mass (kg): 125 **Data Rate (kbps)**: 300, avg
2600, max

PRINCIPAL PURPOSE AND FEATURES: The scientific objectives are:
1. The quantitative measurement of the solar irradiance spectrum at wavelengths between 168 and 365 nm with an uncertainty of 3% in absolute scale and 1% in relative scale and with 0.003 nm resolution. The accuracy of the measurements will be assured by the use of an on-board deuterium continuum calibration lamp.
2. The quantitative measurement by means of solar occultation and/or atmospheric emission observations of the altitude profiles of aeronomically significant species such as OH, NO, ClO, CO, O_3 and H_2O. High resolution (0.0010 nm) will allow the molecular absorption lines to be resolved from the solar Fraunhofer spectrum and will permit a detailed evaluation of the radiation transmitted through the complex Schumann-Runge system of O_2. Absorption by OH, NO, ClO, CO, O_3, and O_2 in the wavelength range 145-365 nm, solar induced resonance fluorescence of OH, and NO, and emission from excited OH produced in the photofragmentation of H_2O will be studied.
3. The quantitative measurement of solar line absorption features with high resolution (0.001 nm) and signal-to-noise ratio (100).
4. The integration of the solar and atmospheric data with the results obtained by other instruments to construct theoretical models of the chemical response of the terrestrial atmosphere to the absorption of solar radiation.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: The STAS instrument is a f/18 Fastie-Ebert spectrometer of 3 m focal length and with a 3600 line/mm grating. The subsystems include a 2.3 m focal length telescope for the high resolution solar and terrestrial atmospheric absorption measurements, a photomultiplier tube, and a 160 element linear array detector for photon detection, bandpass and neutral density filters, and on-board calibration lamps. The major parameters are:

Resolving power ($\lambda/\Delta\lambda$)	$\sim 3 \times 10^5$
Spectral range	145-365 nm
Spectral resolution	0.0010 nm
Field of view (solar)	3 arc min × 0.5 arc sec
Height resolution (terrestrial atmosphere)	≤ 2 km
Signal-to-noise (for most of spectral range)	50-100

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT: R. Arnold, NASA HQ, EB-8
Solar and Terrestrial Atmospheres Spectrometer for Spacelab, Section I: Investigation and Technical Plan, Harvard College Observatory, November 1978

INSTRUMENT: Atmosphere General Circulation Experiment EI-58

STATUS: Planned

CARRIER: Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

A dielectric fluid will be between two concentric and co-rotation spheres. A voltage will be maintained across the spheres. Motions will be driven by a latitudinal temperature gradient applied to the inner sphere, and the outer sphere will be held at a temperature warmer than any inner sphere temperature. These imposed conditions provide the correct essential configurations for the forces of buoyancy and rotation which drive the general circulation of the atmosphere. It is planned to make flow measurements by photographing the movement of streaks made in the fluid by exciting a photochromic dye. The thermal structure of the fluid will be measured using a Moire fringe technique. Other similar techniques, such as shadowgraphs and schlieren, are also being examined.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

A modification of the Geophysical Fluid Flow Cell for Spacelab 1. See this particular description in the Spacelab mission description. General features and such are conceptual at this time.

SOURCE/CONTACT: J. Theon, NASA HQ, EBC-8; William W. Fowlis, MSFC
Atmospheric General Circulation Experiment, W.W. Fowlis, G. H. Fichtl, J. Guida, MSF, June 1978 in response to PSTA AMPA-TIB

INSTRUMENT: Lightning Mapper EI-59

STATUS: Planned

CARRIER: Geosynchronous satellite of opportunity centered at about 100° W long

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): $<1\ m^3$

Power Requirement (We): <50

Mass (kg): <50

Data Rate (kbps): 1

PRINCIPAL PURPOSE AND FEATURES: Constant viewing, flash counting, and locating sensor for placement on geosynchronous platform. Features: simultaneous counting in 10 × 10 km "boxes" over critical areas; desirability to distinguish between cloud-to-cloud and cloud-to-ground strokes (optical and/or RF techniques required); 15-min repeat cycle on map readout (low data rate); real-time display to be provided to power company distribution centers, Forest Service, DoD, airlines; data to be integrated and mapped weekly and monthly for use by construction users and atmospheric electricity researchers.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

The preliminary requirements of the LM can be accomplished by four different conceptual instruments described on the following pages.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This particular instrument is conceptual and its features will change as its status changes.

SOURCE/CONTACT:

J. Dodge, NASA HQ, EBT-8

INSTRUMENT: Lightning Mapper (Cont.) EI-59

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

Sensor A

Field of view: full earth as viewed from geostationary

Spatial resolution: observation cell as small as possible--continuous observation all cells

Data update interval: 15 minutes

Information reported: (1) total lightning flash count in each cell having at least one flash; detect ΔI in $\Delta T \sim 100$ msec; (2) lightning flash to ground count in each cell having at least one flash to ground; (3) number of strokes in each ground flash; detect ΔI in $\Delta T \sim 1$ msec; (4) charge transferred to ground by each stroke.

Sensor B

Field of view: contiguous United States

Spatial resolution: 10 km × 10 km observation cells--continuous observation of all cells

Data update interval: 1 minute

Information reported: (1) total lightning flashes in each cell having at least one flash; detect ΔI in $\Delta T \sim 100$ msec; (2) lightning flashes to ground count in each cell having at least one flash to ground; (3) number of strokes in each ground flash; detect ΔI in $\Delta T \sim 1$ msec; (4) charge transfer to ground by each stroke; (5) return stroke current and rise time; (6) continuing currents; amplitude and duration.

Sensor C

Field of view: pointable under ground control; 1000 km × 1000 km

Spatial resolution: 4 km × 4 km observation cells--continuous observations of all cells

Data update interval: programmable on-board data analysis; stretch the capabilities as far as possible; programmable integration time with ΔT as low as 100 μs and as high as 10 sec.

Information reported: Programmable from ground control. The principal of Sensor C is to provide a research tool. The raw data acquired on board must have the highest resolution in time and space as is technically practical. On-board data processing should be under programmable software control to reduce the data for telemetry. Complimentary software on the ground will provide further data treatment as required by the researcher.

INSTRUMENT: Lightning Mapper (Cont.) EI-59

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

Sensor D

Field of view: pointable within the field of Sensor C; 8 km × 8 km

Spatial resolution: 8 km × 8 km; a single element

Data update interval: programmable. This instrument should be very sensitive and be able to acquire high time resolution (~100 μsec) data or when used in another mode spectral data on lightning (128 spectral channels in 400-700 nm range at 1 msec integration time).

Information requested: Sensor D is viewed as an adjunct capability to the Sensor C research instrument. The experimenter's program points Sensor D to a subset of cells in the Sensor C format. This allows the experimenter to acquire either high time resolution samples with high sensitivity of the activity in a special region or periodic spectra of the special region.

INSTRUMENT: Cloud Radiation Experiment EI-60

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: The cloud radiation experiment will combine active and passive remote observation techniques with direct sampling measurements from aircraft to obtain simultaneous data on the optical characteristics of clouds. A 3 yr program of theoretical investigations, algorithm development, measurements and analyses will be performed. The experimental portion of this experiment will consist of downward-looking remote sensing instruments flown on the NASA WB-57 aircraft simultaneous with the collection of in situ samples of physical and thermodynamic cloud parameters. The data from the airborne sensors will be analyzed and compared in order to validate and assess the accuracy of the remote sensing techniques. The passive component will consist of: the Multispectral Cloud Radiometer (MCR), a 7 channel scanning radiometer with 6 channels in the near infrared and 1 channel in the thermal infrared; the Advanced Microwave Moisture Sensor (AMMS), a scanning 4-channel radiometer operating at 94 and 183 GHz, where the three 183 GHz channels measure total water vapor and the 94 GHz channel maps rain over land; and a set of 3 Eppley radiometers including an uplooking and a downlooking pyrgeometer to measure the upwelling thermal flux. The active component will consist of the Cloud Lidar System (CLS) which is a scanning dual frequency monostatic lidar with one wavelength in the visible and one in the near infrared.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

MCR Channel Characteristics

Channel	Band Center (μm)	Bandwidth (μm)	Reflectivity Range (%)	Signal to Noise Ratio
1	0.7544	0.0014	2 - 120	700
2	0.7610	0.0014	0.1 - 90	700
3	0.7634	0.0010	0.1 - 110	700
4	1.1424	0.074	0 - 60	400
5	1.6386	0.056	0 - 80	400
6	2.165	0.15	1 - 50	400
7	11.403	1.93	emission	NEDT = 0.16 K at 300 K NEDT = 0.6 K at 190 K

INSTRUMENT: Cloud Radiation Experiment (Cont.) EI-60

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

The CLS is a dual frequency monostatic lidar which consists of a laser transmitter co-aligned with a laser receiver system. The laser transmitter is a frequency-doubled, pulsed, neodymium-doped yttrium-aluminum-garnet (Nd:YAG) laser. With the aid of a nonlinear doubling crystal, the system transmits and receives at wavelengths of 1.06 μm and 0.5320 μm simultaneously. The transmitter can produce ten 100 mJ pulses per second at each wavelength. The AMMS is a mechanically scanned microwave radiometer that measures at 94 GHz and at three frequencies separated by 1, 5 and 10 GHz from the 183 GHz water vapor line. It has a 15 cm reflector which provides a 2° beamwidth at 94 GHz and a 1° beamwidth at 183 GHz. The scan is programmable in a ±45° range.

The Eppley pyranometers measure the sum of the spectrally integrated direct and diffuse components of skylight when used in the upward mode, and the spectrally integrated diffusely reflected solar radiation when downlooking. The temperature-compensated thermopiles measure the global radiation over the spectral range from 285 to 2800 nm with an accuracy of ±1-2%. The downlooking precision infrared radiometer (pyrgeometer) measures the integrated reflected and emitted longwave flux over the spectral range from 3 to greater than 50 micrometers.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

R. Schiffer, NASA HQ, EB-8
R. Curran, GSFC, (301) 344-8235
Cloud Radiation Experiment, Proposal to OSTA, June 1979

INSTRUMENT: Doppler Geostationary Imager EI-61

STATUS: Planned

CARRIER: Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Information unavailable at this time.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

J. Theon, NASA HQ, EBC-8

INSTRUMENT: Salinity Radiometer EI-62

STATUS: Planned **CARRIER:** Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):
Power Requirement (We):
Mass (kg):
Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To develop a salinity-measuring radiometer for measuring the salt content and patterns of the coastal and ocean waters from space. LaRC feels that by using a 10 m antenna (which would be feasible for deployment during a Shuttle sortie mission), a spatial resolution at L-Band of 20 km could be obtained. The expected accuracy would be of the order of ±0.2 parts per thousand. While the resolution would not be as good as desired, a shuttle experiment built to these requirements would clearly demonstrate the feasibility of measuring salinity from space with the required accuracy and stability. Once that is done, it is simply a matter of using the shuttle capability to erect a larger antenna (to achieve the required resolution of a few kilometers) on a free-flying version of the system.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Possible scale-up of an aircraft program. Instrument is conceptual at this time.

SOURCE/CONTACT:

The Shuttle Oceanographic Instrument Technology Development Program: A Report.
W. Townsend, NASA HQ, EBC-8

INSTRUMENT: Ice Sounder EI-63

STATUS: Planned

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To develop a shuttle-borne VHF ice sounder which would provide global ice-sounding coverage with a grid size of better than 20 km, footprint resolution of a few kilometers cross-track and a few hundred meters along track, a height resolution of 10 to 100 meters depending on the bottom topography, and a sounding capability through up to 4 km of ice. Global, synoptic coverage could be obtained in a single shuttle flight. A radar altimeter could also be added to provide surface topography with about 1-2 m accuracy and 10-50 m resolution.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Concept has been demonstrated in Danish aircraft program. Instrument is conceptual at this time.

SOURCE/CONTACT:

The Shuttle Oceanographic Instrument Technology Development Program: A Report
W. Townsend, NASA HQ, EBC-8

INSTRUMENT: Local Wave Spectra Sensor EI-64

STATUS: Planned

CARRIER: ND

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To obtain localized, in situ, accurate measurements of wave spectra with a near global distribution. Utilizing a near earth orbiting VHF (approximately 50 MHz) dual frequency transmitter having HF separation (5 MHz or so), this system would take advantage of the Bragg scattering properties of ocean waves to determine the wave spectra around a receiving site (10-20 km coverage) when the satellite passes overhead while radiating toward the ocean surface. This is an updated version of the old bistatic radar, but with satellite-type geometry thus elimination problems associated with aircraft radars. Additionally, by operating at VHF, the problems associated with the ionosphere are eliminated.

ASSOCIATED RANGES AND/OR RESOLUTION:

Wave spectra.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Possible joint NOAA/NASA feasability study in the future. Very conceptual in nature at this time.

SOURCE/CONTACT: The Shuttle Oceanographic Instrument Technology Development Program: A Report - Summary and Recommendations, William F. Townsend, November 1979. W. Townsend, NASA HQ, EBC-8.

INSTRUMENT: Laser Altimeter EI-65

STATUS: Planned

CARRIER: NOSS or Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To develop a laser altimeter system that could provide fine scale, high resolution topographic mapping of the ice surface as well as ranging to fixed retroreflective targets for the purposes of precision orbit determination and/or measuring ice sheet motion. Additionally, when operated simultaneously with a radar altimeter system, it could provide a calibration of that system as well as a measurement of ionospheric and wet tropospheric losses. Under microprocessor control, a short pulse ND:YAG laser would transmit at 10-20 pulses per second to the surface and, using the scanning capability, to retroreflective targets at known locations, while providing an overall ranging accuracy of 5-10 cm.

ASSOCIATED RANGES AND/OR RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Technology problems in precision orbit determination, laser tracking system for corner cubes on ice sheets, lifetime of laser flash tubes (about 5×10^6 pulses SOA). Under active consideration as a NOSS research experiment.

SOURCE/CONTACT: The Shuttle Oceanographic Instrument Technology Development Program: A Report - Summary and Recommendations, William F. Townsend, November 1979. W. Townsend, NASA HQ, EBC-8.

INSTRUMENT: Ocean Synthetic Aperture Radar EI-66

STATUS: Planned

CARRIER:

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

An augmentation of the SIR-A instrument for ocean capability requirements and near real-time on-board imaging processing (probably an optical processor). Transmittal capability to ships performing in situ observation of long-term phenomena.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

A possible new start proposal. Conceptual in nature at this time.

SOURCE/CONTACT:

W. Townsend, NASA HQ, EBC-8

INSTRUMENT: Pushbroom Radiometer EI-67

STATUS: Planned

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To produce a radiometer that will replace the LAMMR (because of its technical problems). The Pushbroom Radiometer would employ a very large 100-m spherical reflector with multiple (perhaps as many as 100) feeds and radiometers to map out a high resolution (subkilometer would be possible) swath. It would eliminate the LAMMR-related problems of the mechnically spinning antenna and questions related to using total power radiometers (they would not be required since there is adequate dwell time).

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

An OAST aircraft program is under way to test concept. Instrument is conceptual at this time.

SOURCE/CONTACT: The Shuttle Oceanographic Instrument Technology Development Program: A Report - Summary and Recommendations, William F. Townsend, November 1979. W. Townsend, NASA HQ, EBC-8.

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COMMUNICATIONS

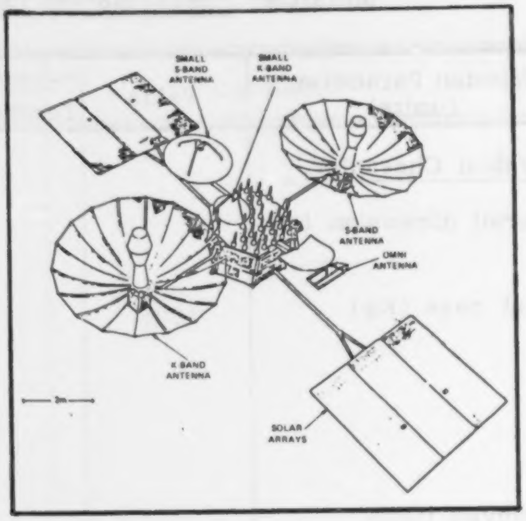
The Communications program consists of two major elements: (1) increased support of spacecraft instrument data in the form of 85% coverage of low earth orbits, augmentation of deep space probe data capabilities, and data processing enhancements to satellite data streams; and (2) the technology for the growth of satellite communications requiring long-term, high-risk, and higher cost technology development.

Communications Missions

NO.	
C-1	Tracking and Data Relay Satellite System (TDRSS) is to provide a tracking and data relay to replace most of STDN network.
C-2	Search and Rescue Mission is to provide the technical basis for a world-wide satellite-aided search and rescue system.
C-3	Application Data Service Development is to economically and efficiently meet future OSTA data access and integration needs.
C-4	30/20 GHz Antenna Communication Satellite Wideband Program will develop the state of the art in multibeam antenna and on-board switching systems to provide significant increases in communication capacity.
C-5	Geostationary Platform Demonstration will have a mix of communication, science, and applications payloads on a single platform.

MISSION: Tracking and Data Relay Satellite System (TDRSS) C-1

Status:	Approved
Lifetime:	10 years
Launch and Transfer Vehicles:	Shuttle/IUS
Operational Location:	GEO
Total Mass at Operational Location:	1905 kg
Average Operational Power:	1.8 kW



OBJECTIVE:

Leased service (Western Union) to provide tracking and data relay to replace most of STDN network.

DESCRIPTION:

Four 3-axis stabilized spacecraft (2 NASA, 1 Advanced Westar, 1 on-orbit spare) whose communication payload includes: NASA transponders at 2 and 14 GHz for satellite data, tracking, telemetry, and command; Westar transponders at 4 and 6 GHz with total capacity of twelve 36-MHz channels; advanced Westar transponders at 12 and 14 GHz with total capacity of four 250-Mbps data streams (equivalent to 11,500 two-way voice circuits); a switch and switch control unit providing spacecraft switched time division multiple access (SSTDMA) capability for the 12 and 14 GHz channels.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

TRW DSSG Quest, Spring 1978, pp. 46-70

Tracking and Data Relay Satellite System, System Design Report, Vol. 1, 23 August 1979.

CONTACTS:

R. Aller, TX-1

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tracking and Data Relay Satellite System (TDRSS) C-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimension (m)			
Total mass (kg)	1905		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	3650		
Number of spacecraft	4		
Orbit			
Altitude (km)	35,786		
Inclination (deg)	0		

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tracking and Data Relay Satellite System (TDRSS) C-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)	[1] 3.8×10^{-3} to 7.7×10^{-3}		1-axis Antenna pointing
Stability (mrad)			
Type of control system			3-axis active control, earth horizon and sun sensors

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tracking and Data Relay Satellite System (TDRSS) C-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	1.8		EOL
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	uplink/up to 250 Mbps downlink/up to 250 Mbps		SSTDMA
Frequency (GHz)	14.6 to 15.25 13.4 to 14.05		composite uplink composite downlink
Bandwidth (MHz)	50 625 650		signal bandwidth uplink total downlink total
RF power (W)			
Noise temperature (K)			
Gain (dB)	~18		
Beam number	1		

COMMUNICATIONS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tracking and Data Relay Satellite System (TDRSS) C-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	600		(est.) 10 year mission
Thrust level (N)			monomethyl hydrazine
I_{sp} of stages (sec)	varies		

COMMUNICATIONS

MISSION: Search and Rescue Mission C-2

Status: Approved

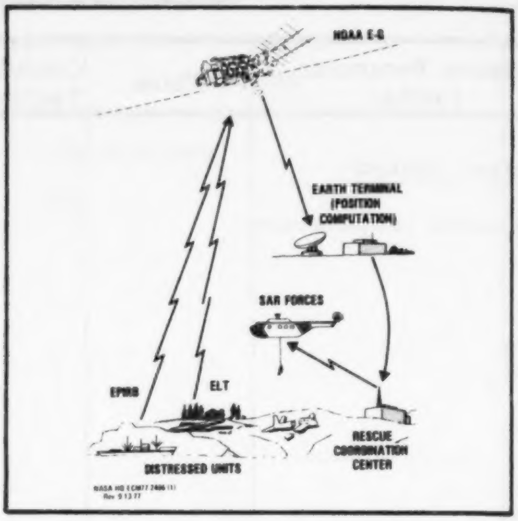
Lifetime: 1-2 years

Launch and Transfer Vehicles: Atlas-F

Operational Location: 834 km altitude
98.8° inclination

Total Mass at Operational Location: 850 kg

Average Operational Power: 98 W



OBJECTIVE: Detect and locate existing aircraft and ship distress beacons during emergencies. Detect and locate an advanced aircraft and ship distress beacon during simulated emergencies. Provide the technical base for a worldwide satellite-aided search and rescue system.

DESCRIPTION:
A modification of the third generation operational weather satellites used by NOAA. The payload package is carried as part of NOAA-E, F, and G.

The basic concept of the search and rescue mission is illustrated above. The signals radiated by either an ELT or an EPIRB are detected by a polar-orbiting spacecraft equipped with suitable receivers. These signals are then relayed to a local user Earth Terminal (LUT) where the signals are processed to determine the location of the ELT or EPIRB. The fact that an alert has been detected, and the location of the ELT or EPIRB is then relayed to an appropriate Rescue Coordination Center for initiation of the search and rescue activities.

An extremely important element of the present mission is that it will carry receivers designed to operate at 406 MHz, a frequency approved at the last World Administrative Radio Conference for ground to satellite search and rescue use. Operation at 406 MHz with ELT's and EPIRB's specifically designed for satellite detection will provide both higher probability of detection and enhanced location accuracy. Thus, the concept for the future envisions the deployment of a system which would provide service for existing ELT's and EPIRB's operating at 121.5 and 243 MHz while allowing for gradual phase-in of the more effective 406 MHz units as they are acquired by the users.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT:
Three frequency transponder, 406 MHz receiver/processor.

REFERENCES: OSTA Program Management Report, 4th Quarter 1978.

CONTACTS: T. McGunigal, NASA HQ, EC

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Search and Rescue Mission C-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total Mass (kg)	850		
Instruments	43.2		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	365-730		
Number of spacecraft	3		NOAA-E, F and G
Orbit			
Altitude (km)	834		Sun synchronous
Inclination (deg)	98		

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Search and Rescue Mission C-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (We)	93		
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			
Frequency (GHz)			
Bandwidth (MHz)			
RF power (W)			
Noise temperature (K)			
Gain (dB)			

MISSION: Application Data Service Development C-3

Status: Planned

Lifetime:

Launch and Transfer Vehicles: NA

Operational Location: NA

Total Mass at Operational Location: NA

Average Operational Power: NA

OBJECTIVE:

The ADS objective is to economically and efficiently meet future OSTA data access and integration needs.

DESCRIPTION:

This objective will be met by implementing a network service (ADS) to intercommunicate the various applications data systems and make their products mutually interchangeable. The network service will permit diverse applications users to access multiple data bases using common system formats and common data standards. It will also provide cataloging and data integration services to increase data visibility and provide more directly useable products.

CRITICAL TECHNOLOGY NEEDS:

None

INSTRUMENT OR EXPERIMENT COMPLEMENT:

NA

REFERENCES:

CONTACTS:

1. J. Heuser, NASA HQ, ESI

MISSION: 30/20 GHz Antenna Wideband Communications Satellite Program C-4

Status:	Planned
Lifetime:	2 years
Launch and Transfer Vehicles:	Shuttle/SSUS
Operational Location:	GEO
Total Mass at Operational Location:	1000 & 1250 kg
Average Operational Power:	500 & 4000 W

OBJECTIVE:

Provide growth capability for satellite communications by developing components for the 30/20 GHz band allocated to the Fixed Satellite Communications Service, by developing multiple beam space craft antennas with frequency re-use, and by developing on-board signal switching systems. Demonstrate innovative communications in experimental spacecraft incorporating these technological developments.

DESCRIPTION:

Possible proof-of-concept flight units demonstrating trunking services in 1986, and Customer Premise Service (CPS) in 1988.

CRITICAL TECHNOLOGY NEEDS:

Components operating in the 30/20 GHz Band, multiple beam antennas with frequency re-use capabilities, on-board signal switching and processing systems.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

30/20 GHz Communications Transponders

REFERENCES: Microwaves, June 1979, pp. 13-15; NASA Five-Year Plan, 1980-84; Technological Priorities for Future Satellite Communication, GSFC, July 1978; Large Space Antenna Technology Telecommunications User Requirements & Satellite Conceptual Designs, JPL-730-23, 8/15/78; Communications Program Review, 4/23/79

CONTACTS:

J. McElroy, NASA HQ, EC-4

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: 30/20 GHz Antenna Wideband Communications Satellite Program C-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	>4		
Total Mass (kg)	1000 & 1250		
Deployed items, size (m)			
1. Trunking antenna	3		
2. CPS antenna	1		
Surface precision (mm)	2.0		RMS, typical
Life			
Flight duration (days)	730		
Number of spacecraft	2		
Orbit			
Altitude (km)	35,786		
Inclination (deg)	0		

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: 30/20 GHz Antenna Wideband Communications Satellite Program C-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Spacecraft processors/ computers			
I/O rates (bps)	2.5×10^3		
Memory size (bits)			
Speed (ops/sec)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)	2		RMS, approximately 0.1°
Stability (mrad)	0.08		per hour, approximately 0.1° daily
Type of control system			

COMMUNICATIONS
MISSION TECHNOLOGY REQUIREMENTS

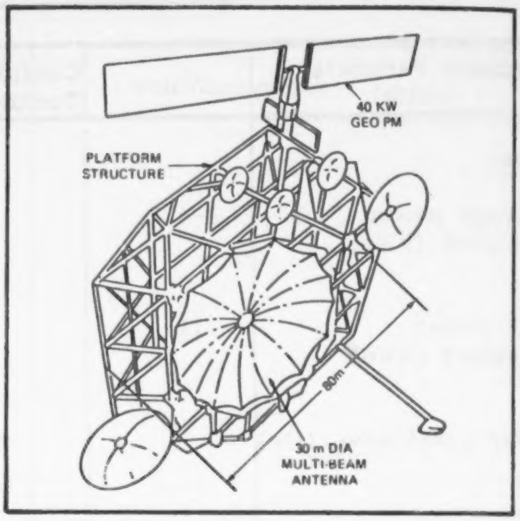
MISSION: 30/20 GHz Antenna Wideband Communications Satellite Program C-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	1-4.2		photovoltaic
Peak power consumed (kWe)	11		
Power breakdown (We)			
Energy Storage			
Storage type			batteries
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			
Frequency (GHz)	30/20		uplink/downlink
Bandwidth (MHz)	2500		downlink/uplink
RF power (W)	3-80		
Noise temperature (K)	300		spacecraft receiver
Beam number	10 & 25		
Gain (dB)	55 & 44		
Cross channel switches	25 × 75		

COMMUNICATIONS

MISSION: Geostationary Platform Demonstration C-5

Status:	Planned
Lifetime:	8 years
Launch and Transfer Vehicles:	Shuttle/OTV
Operational Location:	GEO
Total Mass at Operational Location:	5000-8000 kg
Average Operational Power:	25-50 kW



OBJECTIVE: The real and anticipated growth of requirements for communications and other services at geostationary orbit has reached the level where the use of platforms to aggregate the many missions onto common facilities is both feasible and cost effective. This aggregation can result in reduced cost for the individual users through the sharing of common support services, relief from future congestion or competition for the limited slots on locations available in the geostationary orbit, and enhanced service through the connectivity possible between the communication facilities sharing the platform.

DESCRIPTION: The platform will be launched to low earth (LEO) orbit by Shuttle, assembled and checked out in LEO, and then boosted to geostationary orbit (GEO) for operation. The platform will be visited periodically (two to five years) for the addition, change-out, or servicing of payloads and subsystems. A mix of communication, science, and applications payloads will be accommodated on each platform. The communications payload will operate at C-Band, Ku-Band, and Ka-Band.

CRITICAL TECHNOLOGY NEEDS:

Communications: Base-band switching, multibeam antennas
Platforms: Structure fabrication, assembly, deployment; On-orbit servicing; automated, adaptive control of support resources between payloads

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

Large Communications Platforms Versus Smaller Satellites, Future Systems Inc., Report 221, February 1979.
C. Covault, "Platform Designed for Numerous Uses," Aviation Week and Space Technology, 19 June 1978.
S. W. Fordyce, L. Jaffe, E. C. Hamilton, "Switchboard in the Sky," Spaceflight, pp. 203-217.
W. T. Carey, E. C. Hamilton, Geostationary Platform, MSFC, March 1978.

CONTACTS:

Mark Nolan, NASA HQ, MTC-3, 755-3233

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Platform Demonstration C-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	80 x 30		
Total Mass (kg)	5000-8000		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	2920		
Number of spacecraft	1		
Orbit			
Altitude (km)	35786		CONUS Longitudes
Inclination (deg)	0		

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Platform Demonstration C-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)			
Stability (rad)	5.2×10^{-4} -1.7×10^{-3}		
Type of control system			
Stationkeeping (deg)	±0.1		

COMMUNICATIONS
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Platform Demonstration C-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	25-50		Photovoltaic
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			Multiband system using C, Ku, and Ka nominal communications bandwidths
Frequency (GHz)			
Bandwidth (MHz)			
RF power (W)			
Noise temperature (K)			
Gain (dB)			
Beam Number			

COMMUNICATIONS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Geostationary Platform Demonstration C-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Heat pipe/radiators	273-313		
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

SPACE TRANSPORTATION

The Space Transportation program objective is to provide vehicles to transport missions to their desired destination, either in earth orbit or elsewhere in the solar system and beyond. The current program utilizes expendable vehicles which will be largely replaced by the Space Shuttle. Future emphasis will be on vehicles which extend the basic Shuttle launch capability by providing improvements in payload, cost, and servicing for ranges and duration outside the Shuttle performance envelope.

Space Transportation Missions

NO.

T-1 SCOUT is a relatively inexpensive vehicle that can launch small payloads on a wide variety of missions.

T-2 DELTA 3914 launch vehicle was developed to satisfy the requirements for launching intermediate size spacecraft.

T-3 ATLAS-F is a one and one-half stage launch vehicle.

T-4 ATLAS/CENTAUR is a two and one-half stage vehicle intended as a booster for high-energy orbits.

T-5 Space Transportation System is a partially reusable system designed to reduce the cost and increase the effectiveness of using space for commercial, scientific, and defense needs.

T-6 Spinning Solid Upper Stage provides a low cost, reliable, easy, and early transition of spacecraft from expendable launch vehicles to the STS.

T-7 Multimission Modular Spacecraft provides a standard spacecraft bus that can be used for a range of missions.

T-8 Inertial Upper Stage is to deliver payloads into orbits outside the operating regime of the Shuttle.

T-9 Solar Electric Propulsion Stage provides continuous low-thrust capability for near earth and planetary missions.

T-10 Orbital Transfer Vehicle provides a man-qualified large cryogenic recoverable/refurbishable transfer vehicle.

T-11 Teleoperator Maneuvering System provides remotely manned placement and retrieval of satellites, maintenance repair of satellites, and subsatellite operations.

T-12 Manned GEO Sortie is a man-rated orbital transfer vehicle primarily to be used for service of spacecraft at GEO.

MISSION: Scout T-1

Status: Approved

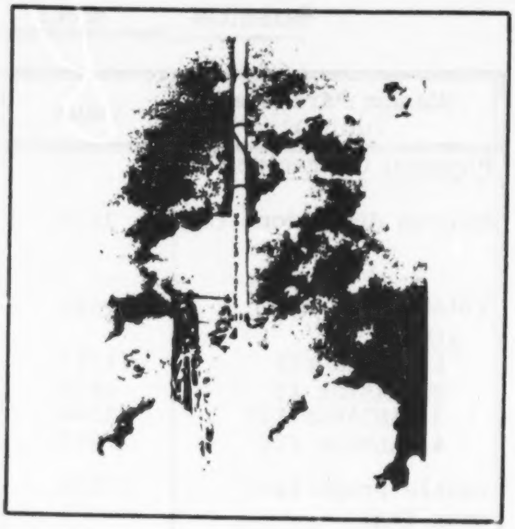
Lifetime:

Launch and Transfer Vehicles:

Operational Location: Wallops, San Marco, WTR

Total Mass at Operational Location:

Average Operational Power:



OBJECTIVE:

A relatively inexpensive vehicle that can launch small payloads.

DESCRIPTION:

Scout is a four-stage solid propellant launch vehicle. The guidance and control system employs a digital programmer and three-axis stabilization for all stages except the spin-stabilized fourth stage.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTO Expendable Launch Vehicle Program (Code OLE), December 1978
Scout Planning Guide, Vought Corp., January 1980.

CONTACTS:

P. E. Goozh, NASA HQ, OLE
L. R. Foster, Jr., LaRC

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Scout T-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	22.5		(Length)
Total mass (kg)	21396		Without payload
Stage			
1. ALGOL III	14715		
2. CASTOR II	4854		
3. ANTARES III	1394		
4. ALTAIR III	313		
Usable propellant mass (kg)	17830		
Stage			
1. ALGOL III	12684		
2. CASTOR II	3716		
3. ANTARES III	1286		
4. ALTAIR III	272		
Deployed items, size (m)	NA		
Payload Capability			
Mass (kg)	165		WTR, 300 nm, 182° circular or on sun synchronous transfer trajectory
	200		Wallops, 300 nm circular orbit, east launch (38°)
	220		San Marco, 300 nm circular, east launch (3°)
Volume (m^3)			
Life			
Flight duration (days)			
Number of spacecraft			
Orbit			
Altitude (km)			Principally LEO
Inclination (deg)			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Scout T-1

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)	None		
Stages (no.)	4	--	
Type of propellant	Solid		
I_{sp} of stages (sec)			
1.	260 (VAC) 229 (Sea level)		ALGOL III (UTC)
2.	280 (VAC)		CASTOR II (THIOKOL)
3.	296 (VAC)		ANTARES III (HERCULES)
4.	270 (VAC)		ALTAIR III (THIOKOL)
Thrust of stages (N)			
1.	485,117(VAC) 423,751(Sea level)		Average
2.	285,610(VAC)		Average
3.	83,100 (VAC)		Average
4.	25,623 (VAC)		Average

MISSION: Delta T-2

Status: Approved

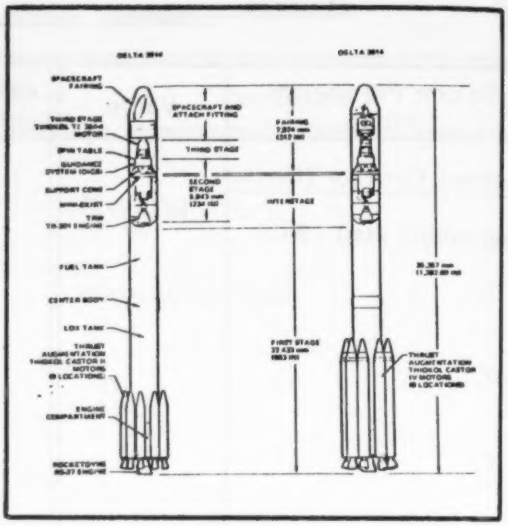
Lifetime:

Launch and Trensfer Vehicles:

Operational Location: WTR, KSC

Total Mass at Operational Location:

Average Operational Power:


SPACECRAFT FAIRING
THIRD STAGE
SPIN TABLE
SUPPORT CONE
TRW TR-201 ENGINE
FUEL TANK
CENTER BODY
LOX TANK
ENGINE COMPARTMENT
ROCKETDYNE RS-27 ENGINE
SPACECRAFT AND ATTACH FITTING
THIRD STAGE
SECOND STAGE
INTERSTAGE
FIRST STAGE
THRUST AUGMENTATION THIOKOL CASTOR IV MOTORS

OBJECTIVE:

The Delta launch vehicle was developed to satisfy the requirements for launching intermediate size spacecraft.

DESCRIPTION:

The Delta is presently operational with 2- and 3-stage configurations and a multi-burn second stage capability. The booster stage is the Extended Long Tank Thor utilizing the Rocketdyne RS-27 engine with 3 or 9 Castor II or 9 Castor IV strap-on solid motors. The second stage utilizes the TRW TR-201 propulsion system and has a restart capability. Third stages include the Thiokol TE-364-3 and 4 solid motors with spin stabilization. The guidance system for the first and second stage is mounted in the second stage, and consists of a Hamilton-Standard Inertial Measurement Unit and Delco Guidance Computer. Delta has evolved through 12 main configurations and improved capability versions are being developed.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTO Expendable Launch Vehicle Program (Code OLE), December 1978.

CONTACTS:

P. T. Eaton, NASA HQ, OLE
D. Grimes, GSFC

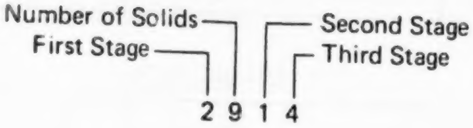
TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Delta

T-2

Physical Character: Overall dimensions (m) - 33

Vehicle Nomenclature The vehicle configurations are described by a four digit number, e.g. Delta 2914. The interpretation of the individual digits is defined as follows:



First Stage

0 Long Tank Thor with Rocketdyne Engine – Vehicle of this configuration are shown in the text as containing the last 3 digits only.
1 Extended Long Tank Thor with Rocketdyne MB-3 Engine and Castor II's.
2 Extended Long Tank Thor with Rocketdyne RS-27 Engine and Castor II's.
3 Extended Long Tank Thor with Rockdyne RS-27 Engine and Castor IV's.

Number of Solids

3 to 9 – Number of First Stage strap-on solid motors.

Second Stage

0 1651 mm (65 in) diameter second stage and fairing with Aerojet General AJ10-118F propulsion system.
1 2438 mm (96 in) diameter second stage and fairing with the TRW Systems TR-201 propulsion system.

Third Stage

0 No third stage
3 Thiokol TE-364-3.
4 Thiokol TE-364-4.

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Delta T-2

VEHICLE STAGE CHARACTERISTICS

Stage No.	1st Stage Aug-2914	1st Stage Aug-3914	1	2	3
Stage Designation	Castor II	Castor IV	Thor	Delta	TE364-4†
Liftoff Mass, kg	40,272*	97,479*	84,308	6,134	1,124
Usable Propellants, kg	33,487*	84,151*	79,131	4,542	1,039
Total Thrust (vac), N	2.339×10^{6}*	3.883×10^{6}*	1.0217×10^{6}	44,190	61,855
Sea Level Thrust, N	2.089×10^{6}*	3.415×10^{6}*	912,200		

ENGINE DATA

Engine Designation	TX-354-5	TX-526-2	RS-27	TR-201	TE-364-4
Type of Engine	Solid	Solid	Pump Fed	Press. Fed	Solid
Thrust/Engine (vac), N	259,880	431,400	1.0217×10^{6}	44,188	61,855
Specific Impulse (vac), $lb_f\cdot sec/lb_m$	266.1	262.4	292.2	300.8	285
Fuel	Solid	Solid	RP-1	UDMH/N_2H_4	Solid
Oxidizer	Solid	Solid	LOX	NTO	Solid
Sea Level Thrust, N	232,067	377,315	912,250		
I_{sp}, $lb_f\cdot sec/lb_m$	237.6	229.5	262.2		

MANUFACTURER

Vehicle	MDAC	MDAC	MDAC	MDAC	MDAC
Engine	Thiokol	Thiokol	Rocketdyne	TRW	Thiokol
Guidance				HSSC/Delco	

CONVERSION FACTORS

$lb_f\cdot sec/lb_m \times 9.81 = N\cdot sec/kg$

---

*Total values for nine solid rocket motors.

†The TE-364-4 propellant can be off-loaded to 964 kg.

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Delta T-2

Approximate Payload Capabilities (kg)

300 n mi Circular

	WTR Polar	KSC East Launch	Sync. Transfer Trajectory	Sun Synch. Transfer Trajectory
2914			723	
3914			900	
3910	1850	2700		1800
3910/PAM*			1090	
†3920/PAM			1245	

*PAM is a SSUS-D adapted for Delta use.

†3920 will use a new larger second stage tank. A further modification will be use of a liquid third stage developed for the Titan transtage.

MISSION: Atlas-F T-3

Status: Approved

Lifetime:

Launch and Transfer Vehicles:

Operational Location: WTR

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE:

Atlas F exploits obsolete ballistic missile capabilities to provide relatively inexpensive, but limited capacity, space launch.

DESCRIPTION:

Atlas F is a one and one-half stage launch vehicle. Atlas F vehicles were originally built as ballistic missiles and were maintained in flight ready status for a number of years. These vehicles are no longer used as ballistic missiles. They are refurbished under the Vandenburg Atlas Modification Program (VAMP) and are now being used as space launch vehicles. The Atlas F does not have a restart capability and can only deliver payloads to low altitude orbital injection points. On-board spacecraft kick motors are used to achieve final injection into the desired orbit. Atlas F is launched only from WTR and is radio guided. "Half stage" describes the dropping of two of the three engines when their thrust is no longer needed to maintain acceleration. The Atlas F program was initiated in 1976 and the first vehicle flew in 1978.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTO Expendable Launch Vehicles Program (Code OLE), December 1978.

CONTACTS:

J. A. Salmanson, NASA HQ, OLE

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Atlas-F T-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	30		Length
Total mass (kg)	118,448		Without payload
Usable propellant mass (kg)	112,098		
Deployed items, size (m)			
1.			
2.			
Payload Capability			
Mass (kg)	100	- - - - - - - - - - -	WTR, 300 nm polar circular orbit
Volume (m^3)	1000	- - - - - - - - - - -	WTR, ballistic (sun synchronous orbit transfer trajectory). Roughly 800 kg can be inserted into orbit with varied upper staging. These payload numbers should be considered to have ±10% envelopes.
Life			
Flight duration (days)			
Number of spacecraft			
Orbit			
Altitude (km)			LEO insertion only
Inclination (deg)			

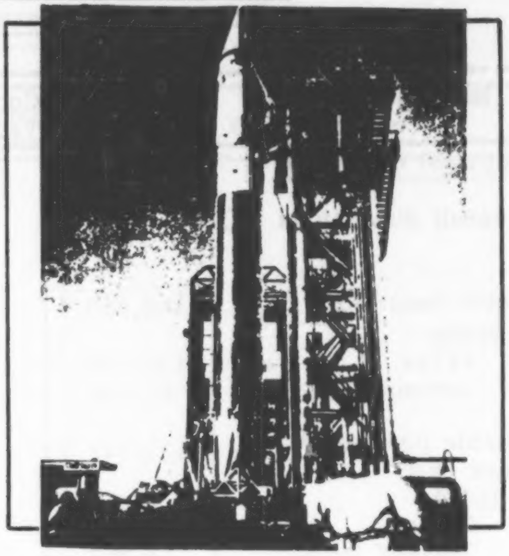
TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Atlas-F T-3

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)	NA		
Stages (no.)	1 1/2		
Type of propellant	RP-1/LOX		
I_{sp} of stages (sec)			
1/2.	290 (Vac) 252 (Sea level)		LR89-NA-5 (2 engines) Rocketdyne
1.	312 (Vac) 214 (Sea level		LR105-NA-5 (1 engine) Rocketdyne
Thrust of stages (N)			
1/2.	8.56×10^5 (Vac) 7.34×10^5 (Sea level)		Each Engine
1.	3.65×10^5 (Vac) 2.54×10^5 (Sea level)		

TRANSPORTATION

MISSION: Atlas/Centaur T-4



Status:	Approved
Lifetime:	
Launch and Transfer Vehicles:	
Operational Location:	KSC
Total Mass at Operational Location:	
Average Operational Power:	

OBJECTIVE:

Altas/Centaur is a two and one-half stage vehicle intended as a booster for high energy missions, particularly lunar and planetary missions and synchronous orbit missions.

DESCRIPTION:

The Atlas (SLV-3D) is an improved version of the early Atlas vehicles. The Atlas/Centaur is capable of either a direct ascent (one-burn of the Centaur stage) or a parking orbit (two-burn) flight path. The guidance system, located in the Centaur, uses an inertial reference and a digital computer to provide orientation and steering signals to both stages. A launch complex including two pads and logistic support has been established at the Eastern Test Range.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTO Expendable Launch Vehicle Program (Code OLE), December 1978.

CONTACTS:

F. R. Schmidt, NASA HQ, OLE
L. J. Ross, LeRC

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Atlas/Centaur T-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	38		
Total mass (kg)	148,350		Without payload
Stage			
Atlas	130,950		
Centaur D-1A	17,400		
Usable propellant mass (kg)	135,127		
Stage			
Atlas	121,600		
Centaur D-1A	13,560		
Deployed items, size (m)			
1.			
2.			
Payload Capability			
Mass (kg)	5000		KSC, 300 nm circular, east launch
	1900		KSC, geosynchronous transfer trajectory
Volume (m^3)			
Life			
Flight duration (days) (coast time)			
Number of spacecraft			
Orbit			
Altitude (km)			HEO, GEO, interplanetary
Inclination (deg)			

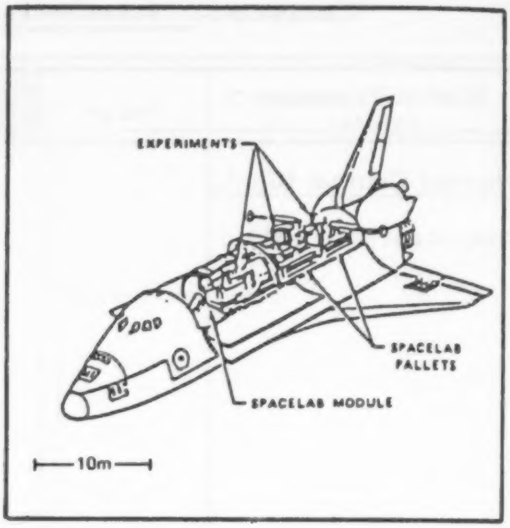
TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Atlas/Centaur T-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)	1		By Centaur on typical mission. Multiple Centaur restarts are possible
Stages (no.)	2 1/2		
Type of propellant	RP-1/LOX LH2/LOX		Atlas 1 1/2 stage Centaur
I_{sp} of stages (sec)			
1/2.	295 (Vac) 258 (Sea level)		YLR-89-NA-7 (2 engines) Rocketdyne
1.	307 (Vac) 219 (Sea level)		YLR-105-NA-7 (1 engine) Rocketdyne
2.	445 (Vac)		RL10A-3-3 (2 engines) Pratt & Whitney
Thrust of stages (N)			
1/2.	9.23×10^5 (Vac) 8.24×10^5 (Sea level)		Each engine
1.	3.67×10^5 (Vac) 2.67×10^5 (Sea level)		
2.	6.56×10^4 (Vac)		Each engine

MISSION: Space Transportation System (Shuttle) T-5

Status:	Approved
Lifetime:	
Launch and Transfer Vehicles:	NA
Operational Location:	LEO, KSC, WTR (1984)
Total Mass at Operational Location:	2,000,000 kg 29,500 kg payload
Average Operational Power:	7 kW



OBJECTIVE:

A partially reusable space transportation system designed to reduce the cost and increase the effectiveness of using space for commercial, scientific, and defense needs.

DESCRIPTION: The Shuttle flight systems is composed of the orbiter, an external tank (ET) that contains the ascent propellant used by the three orbiter main engines, and two solid rocket boosters (SRBs). The orbiter and SRBs are reusable; the external tank is expended on each launch. The orbiter is designed to carry a crew of up to seven and the payloads. The smaller engines of the orbital maneuvering system (OMS) provide propulsive energy for orbit insertion, retrograde, and maneuvering capability during space flight. A reaction control system provides for precision velocity adjustments and attitude control. During atmospheric flight, the orbiter is controlled by its aerodynamic surfaces. A turnaround time as short as two weeks is planned between touchdown and relaunch.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

Space Shuttle, JSC, 1976; Space Transportation User Handbook, JSC, July 1977. Space Shuttle System Payload Accomodations, JSC07700, Vol. XIV, Revision F, 22 September 1978.

CONTACTS:

H. Roseman, NASA HQ, MSH-7

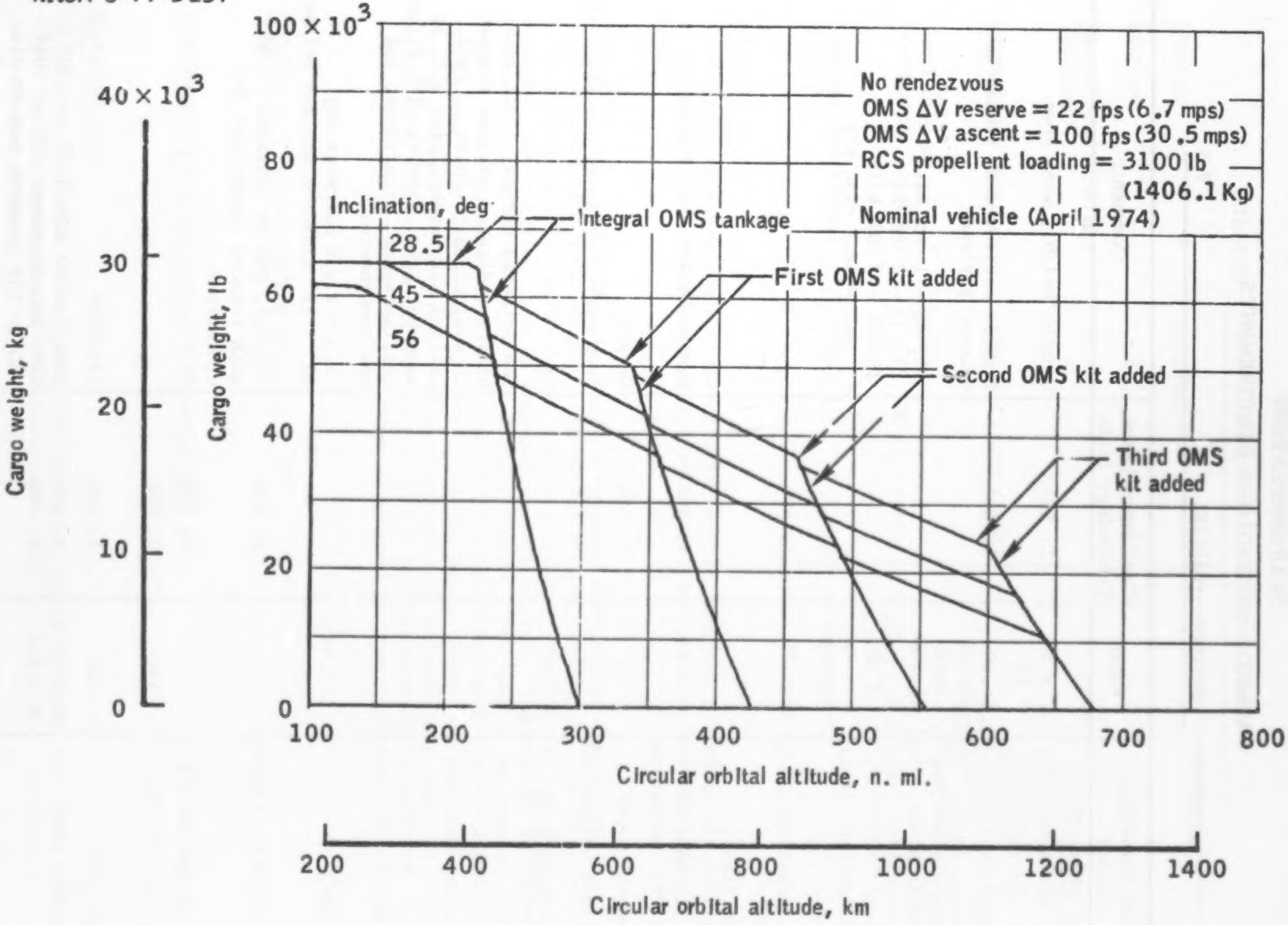
TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Shuttle - ORBITER T-5

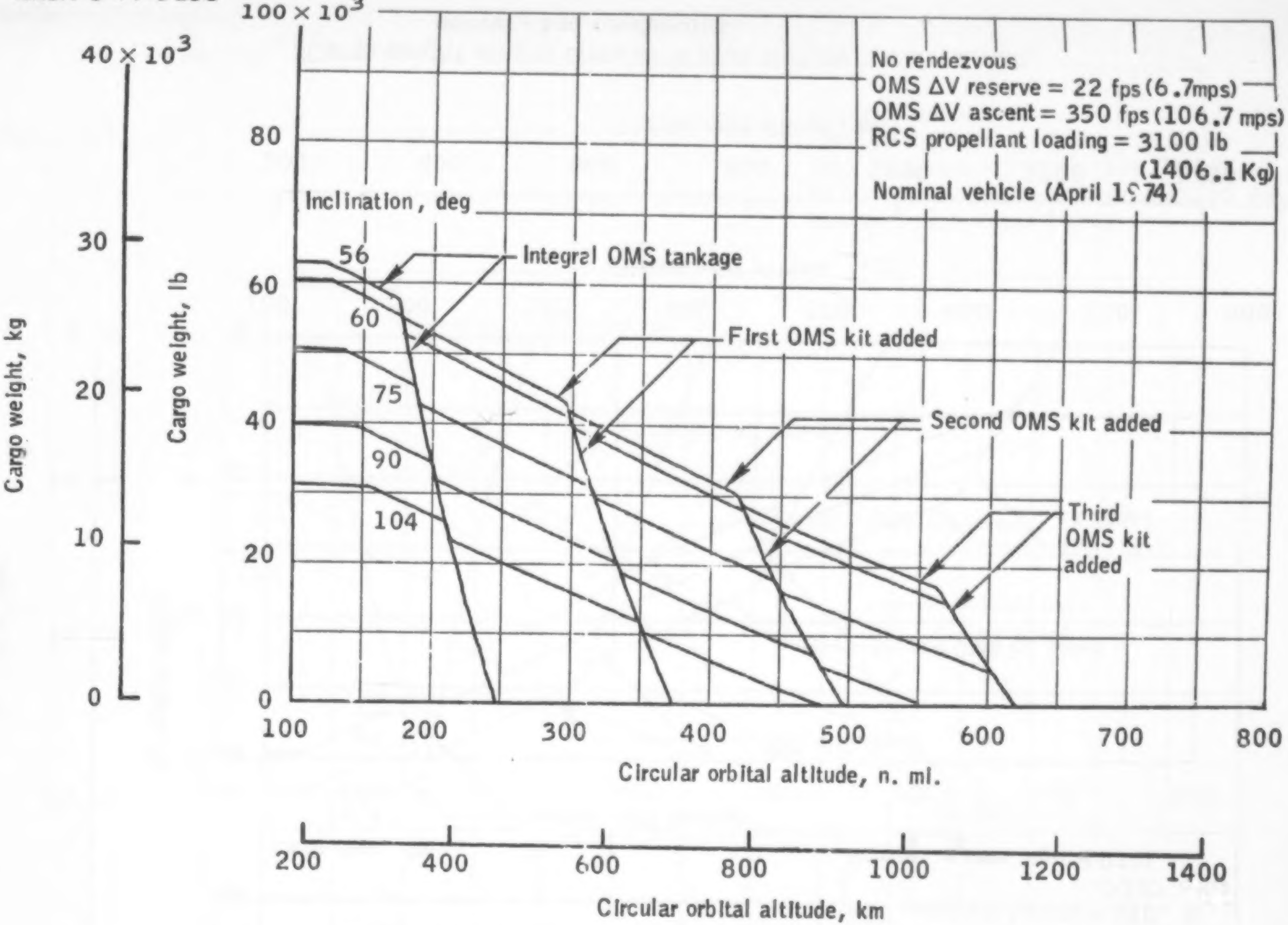
Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	37 × 17 × 24	1, SOA	Length, height, wing span
Total mass (kg)	86,000	1, SOA	Typical orbiter mass breakdown without payload
Inert	68,000		
Non-propulsive fluid	2,100		
Personnel group	1,100		6,466 - 1 OMS kit
RCS propellant (full load)	3,350		12,533 - 2 OMS kits 18,601 - 3 OMS kits
OMS propellant (full load)	11,400		861 - each cryo kit
Usable propellant mass (kg)	14,750	1, SOA	
Deployed items, size (m)			
1. Deployment/retrieval mechanism	15.24	1, SOA	Remote manipulator system
2. Payload doors	18	1, SOA	Length
Pressurized volume (m^3)	71.5	1, SOA	Crew cabin, ordinary sea level air
Payload Capability			
Mass (kg)			See attached curves: full capability indicated will be reached in evolutionary growth in 1983. Initial KSC capabilities will be somewhat less, varying with flight configuration, experience, and new components.
Volume (m^3)	1,414		18.3 × 4.6 m diameter bay 60' × 15' diameter payload volume
Life			
Flight duration (days)	7	1, SOA	Typical, can be extended to 30 with reduced capability for operations.
Number of spacecraft	4	1, SOA	4-5
Launch interval (hrs)	160	1, SOA	
Orbit			
Altitude (km)	185	1, SOA	185-1110
Inclination (deg)	28.5 to 57	1, SOA	KSC: launch azimuth 35 to 120°
	70 - 104	1, SOA	WTR: launch azimuth 158 to 201° 140 to 158 possible but ET disposal problems require mission modification (56-70 inclination)

NASA-S-77-3157



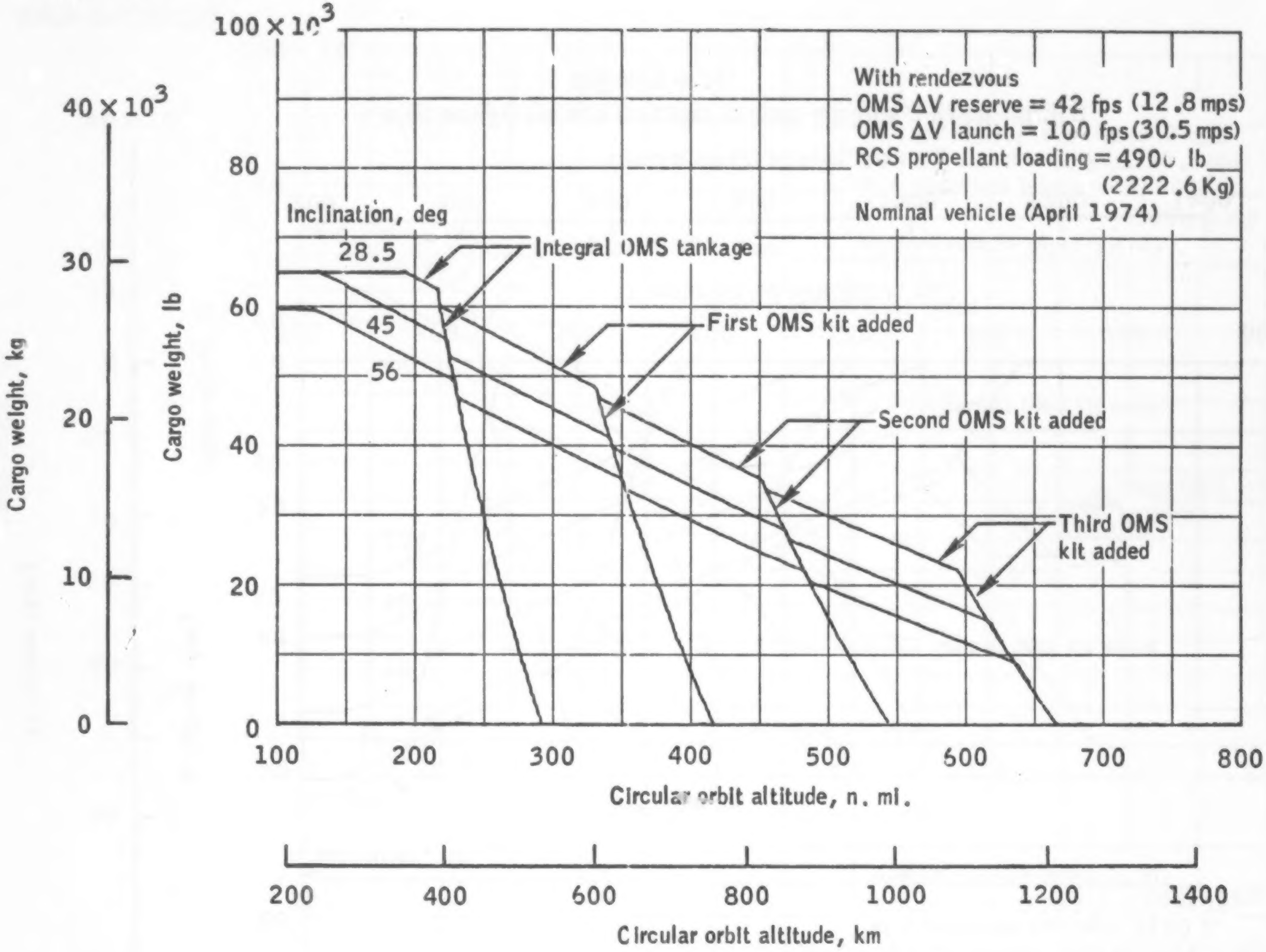
Cargo weight versus circular orbital altitude - KSC launch, delivery only.

NASA-S-77-3158



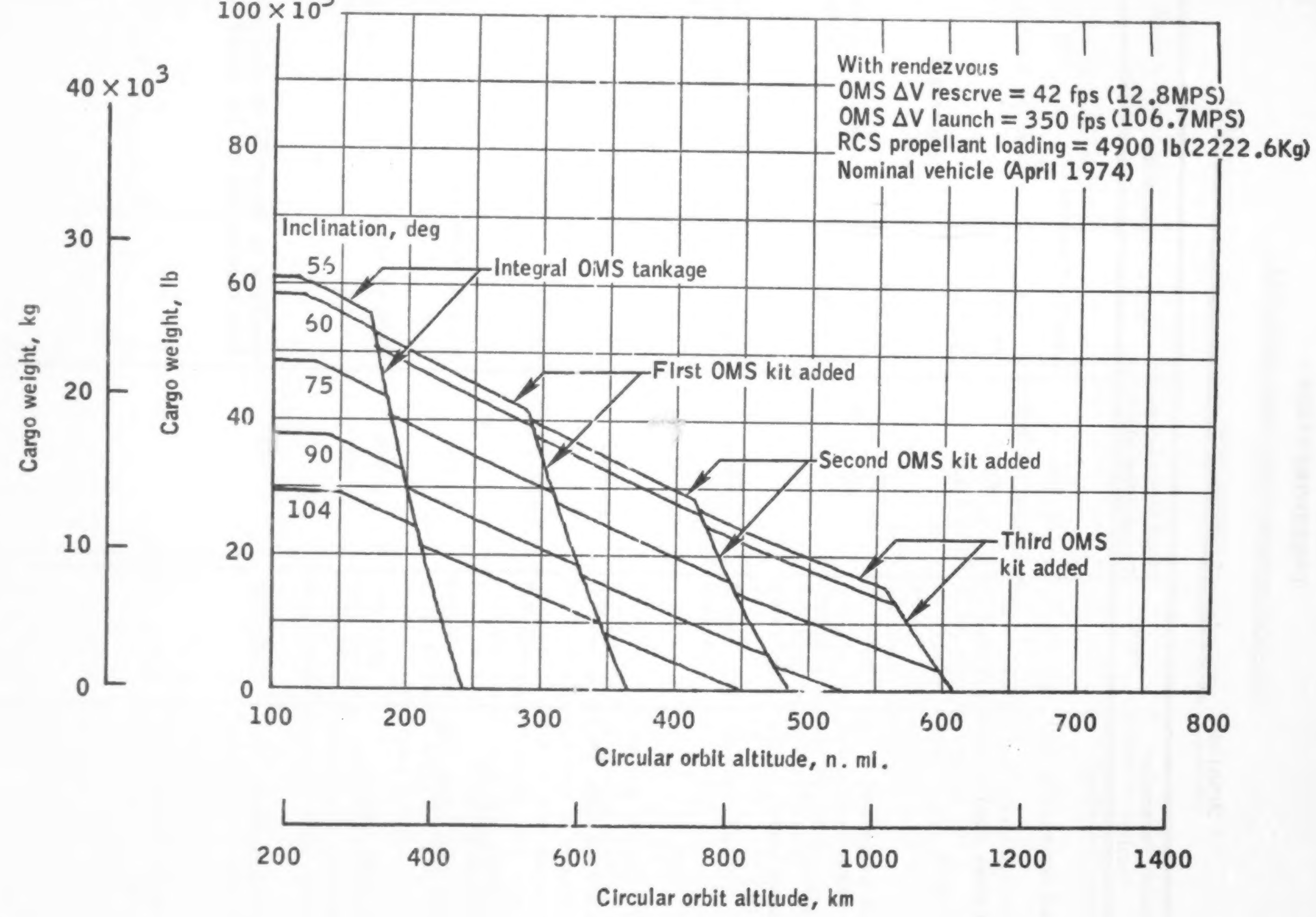
Cargo weight versus circular orbital altitude - VAFB launch, delivery only.

NASA-S-77-3160



Cargo weight versus circular orbital altitude - KSC launch, delivery and rendezvous.

NASA-S-77-3161



Cargo weight versus circular orbital altitude - VAFB launch, delivery and rendezvous.

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TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Shuttle - EXTERNAL TANK T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	47 × 8.7	1, SOA	Length, diameter
		Representative Numbers	
Total mass (kg)	748,169	1, SOA	748,193 Lightweight tank
Dry mass	35,652	1, SOA	31,753
Usable propellant mass (kg)	710,061	1, SOA	714,217
Residuals (kg)	2,456		2,223
Deployed items, size (m)			
1.			
2.			
Pressurized Vol. (m^3)	2,075	1, SOA	
	SHUTTLE - SOLID ROCKET BOOSTERS		
Physical Character			
Overall dimensions (m)	45.5 × 3.7	1, SOA	Length, diameter
Total mass (kg)	583,000	1, SOA	Each of two
Inerts	81,900	1, SOA	
Usable propellant mass (kg)	501,700	1, SOA	Separate at about 50 km altitude, impact about 280 km downrange.
Deployed items, size (m)			
1.			
2.			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Space Transportation System (Shuttle) T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Guidance & Attitude Control			
Position accuracy (km)	0.1		Varies with time after achieving orbit. Initial errors during first 40 min can be 10^4 m. After navigation fixes using STDN, errors (3σ) of 100 m in the 3 axes are expected.
Pointing accuracy (mrad)	8.7	1, SOA	3-axis, 3σ, using orbiter inertial measuring unit: 7.6 mrad with star sensor updating
Pointing accuracy degradation rate (mrad/hr)	1.7	1, SOA	1 axis, 3σ, no star sensor updates
Stability (mrad)			Depends upon amount of Vernier RCS propellant invested to keep within a deadband: typical numbers are 0.34 mrad deadband 1 axis, 1 min between corrections, 2 kg/hr RCS propellant rate; or 0.034 mrad, 5 s, 10 kg/hr. Bending effects are not included and will require orbital experience to quantify to these levels.
Type of control system			Star sensors, inertial measurement units (IMU), rate gyros, accelerometers, air data sensors

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Space Transportation System (Shuttle) T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			3 - fuel cells
Average power consumed (kWe)	7	1, SOA	14 kW all payloads; 50 kW-h for all payloads available over 7 days;
Peak power consumed (kWe)	30	1, SOA	Approximate, during ascent, descent, and some payload operations
Power breakdown (We)			
Hydraulic Power			3 pumps geared to gas turbines driven by hydrazine decomposition; used for aerodynamic surfaces, engine gimbals and valves, landing gear, ET disconnect
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	Voice/S band uplink/72 kbps PCM telem/S band downlink/192 kbps FM data, TV/S band downlink/5 Mbps PM uplink/Ku band/1 Mbps PM downlink/Ku band/50 Mbps FM downlink/Ku band/5 Mbps		TDRSS, DSN, STDN, DOMSAT STDN TDRSS
Thermal Control			
Component temperature (K)			
1. HRSI	1500		Silica fiber blocks: underside, tail leading edge
2. LRSI	925		Silica fiber blocks, sides
3. RCC	1900		On nose and leading edges, reinforced carbon-carbon
4. RFSI	645		Nylon felt coated with silicone

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Space Transportation System (Shuttle) T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion	ORBITER REACTION CONTROL SYSTEM		
Total ΔV required (m/sec)	6.1	1, SOA	Monomethyl hydrazine and nitrogen tetroxide
Thrust level (N)	3870 111	1, SOA	Main (38): 14 nose, 12x 2 aft Verniers (16)
I_{sp} of stages (sec)	289 228	1, SOA	Main Verniers
Propellants (kg)	3115	1, SOA	
Minimum impulse bit (N-sec)	70.28 3.34	1, SOA	Main Verniers
Propulsion	ORBITER MANEUVERING SYSTEM		
Total ΔV required (m/sec)	305	1, SOA	
Thrust level (N)	26,700	1, SOA	Each of two engines
I_{sp} of stages (sec)	313	1, SOA	Monomethyl hydrazine and nitrogen tetroxide
Propellants (kg)	11,400	1, SOA	

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Space Transportation System (Shuttle) T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Special			
g's (drag)			at 200 km, 2×10^{-5} to 5×10^{-6} at 400 km, 10^{-7} to 2×10^{-8}
		SOLID ROCKET BOOSTERS	
Propulsion			
Total impulse (N-sec)	1.30×10^{9}		20 or more reuses of case, directional controls and electrical system
Restarts (no.)			
Stages (no.)	1		
Type of propellant	Solid		
I_{sp} of stages (sec)			
1.	288	1, SOA	
2.			
3.			
Thrust of stages (N)			
1.	12.9 M	1, SOA	each of 2 engines
2.			
3.			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Space Transportation System (Shuttle) T-5

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Propulsion	ORBITER	MAIN PROPULSION	
Total impulse (N-sec)	2.7×10^9		External tank expendable
Restarts (no.)	NA		
Stages (no.)	1		
Type of propellant	LH_2, LO_2		
I_{sp} of stages (sec)			
1.	390		
2.			
3.			
Thrust of stages (N)			
1.	1.67×10^6	1, SOA	Each of 3 engines, sea level
2.			
3.			

TRANSPORTATION

MISSION: SPINNING SOLID UPPER STAGES T-6

Status:	Approved
Lifetime:	
Launch and Transfer Vehicles:	Shuttle
Operational Location:	LEO
Total Mass at Operational Location:	
Average Operational Power:	

OBJECTIVE:

SSUS's/PAM's are intended to provide low cost, reliable, easy and early transition of spacecraft from expendable launch vehicles to the Space Transportation System.

DESCRIPTION:

Spinning Solid Upper Stages (SSUS) are being developed as a commercial venture by McDonnell Douglas Astronautics Corporation (MDAC). SSUS system hardware and services are offered directly to users by MDAC, except in certain instances where NASA acts as an agent for users. MDAC identifies the SSUS system as PAM (Payload Assist Module). SSUS/PAM is being developed under an agreement between NASA and MDAC. It is available in two sizes: SSUS-A/PAM-A for accommodating Atlas Centaur class spacecraft and SSUS-D/PAM-D for accommodating Delta class spacecraft. Two SSUS-A's with spacecraft can be flown on a single Shuttle flight, as can four SSUS-Ds with their spacecraft. SSUS's/PAM's are solid propellant perigee stage systems, carried into low earth orbit by the Space Shuttle, and are used primarily to place spacecraft on transfer orbits to geosynchronous altitudes. The SSUS/PAM system consists of expendable vehicle hardware plus the reusable airborne support equipment required to interface with the STS orbiter and deploy the SSUS/PAM with spacecraft from the orbiter for its powered flight.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTS Expendable Equipment Division (Code MXS), December 1978.

CONTACTS:

J. Wild, NASA HQ, MXS
M. Kitchen, NASA HQ, MXS
R. Mattson, GSFC

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: SPINNING SOLID UPPER STAGES T-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total mass (kg)	2155 3788		SSUS-D SSUS-A
Usable propellant mass (kg)	1996 3447		SSUS-D SSUS-A
Deployed items, size (m)			
1.			
2.			
Payload Capability			
Mass (kg)	1112 2000		SSUS-D } SSUS-A } into equatorial GEO transfer orbit from due east KSC orbit at 160 nm. Mass of circularization propulsion is included in this "payload." Approximately half of this "payload" is expended typically for circularization.
Volume (m^3)			
Life			
Flight duration (days)			
Number of spacecraft			
Orbit			
Altitude (km)			LEO to GEO/polar/sun synchronous
Inclination (deg)			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

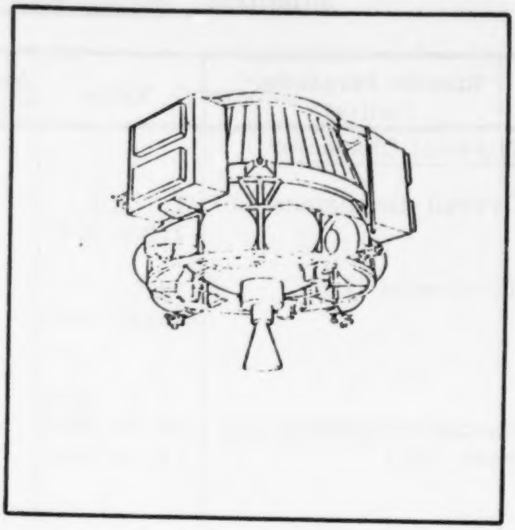
MISSION: SPINNING SOLID UPPER STAGES T-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)			
Stages (no.)	1		
Type of propellant	SOLID		
I_{sp} of stages (vac)			lb_f x sec/lb_m
1.	277 286		SSUS-A, TU-844 SSUS-D, STAR 48
2.			
3.			
Thrust of stages (N)			
1.	3.43×10^5 1.47×10^5		SSUS-A SSUS-D
2.			
3.			

TRANSPORTATION

MISSION: MULTIMISSION MODULAR SPACECRAFT T-7

Status:	Approved
Lifetime:	2 years
Launch and Transfer Vehicles:	Delta/Shuttle/ Atlas Agena
Operational Location:	500-1600 km
Total Mass at Operational Location:	665 kg
Average Operational Power:	1200 W



OBJECTIVE: Provides a standard spacecraft bus that can be used for a range of missions.

DESCRIPTION: The Multimission Modular Spacecraft (MMS) will support a variety of earth orbiting missions requiring solar, stellar, or earth pointing. Additionally, it can support special-purpose programs such as space manufacturing or low-g biological missions. It can be launched by the Delta or the Space Transportation System (STS). It can also be accommodated on the Atlas-Agena with an 8-ft diameter or larger fairing, or the Titan. It can be used at orbital altitudes from low earth to geosynchronous. It is available to support US Government, foreign government, and commerical space programs. It presents a standardized telemetry and command interface both for integration, test and on-orbit operations with the Ground Space Tracking and Data Network (GSTDN) and the Tracking and Data Relay Satellite System (TDRSS). The multimission versatility of the MMS is accomplished by combining the base-line MMS with mission options and mission unique equipment to meet the specific requirements of the user.

CRITICAL TECHNOLOGY NEEDS: None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Communications and data handling, power, and attitude control. Mission unique subsystem elements such as tape recorders, additional batteries, antenna systems, solar arrays, and a propulsion/actuation module are also available.

REFERENCES: NASA Catalog of Standard Hardware, NASA HQ, 7 July 1978; Multimission Modular Spacecraft External Interface Specifications and User's Guide, GSFC, S-700-11, April 1978; Multimission Modular Spacecraft Mark-II Concept, Preliminary External Interface Specification and User's Guide, Volume II, S-700-11, GSFC, January 1979.

CONTACTS:
M. McDonald, NASA HQ, ST-5

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MULTIMISSION MODULAR SPACECRAFT T-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	1.7 x 2		h x dia, Mark I without propulsion modules
	2.9 x 3.6		h x dia, Mark II
Total mass (kg)	1220 4048		Mark I Mark II without payload
Usable propellant mass (kg)	up to 76		Mark I, Option I (standard)
	476		Mark I, Option II (PM-II propulsion module requires modest development)
	2860		Mark II
			Mark I, Option I and Mark II exist as designs only (May 80)
Payload Capability			
Mass (kg)	4000 -10,000		
Volume (m^3)			
Life			
Flight duration (days)	730		
Number of spacecraft			
Orbit			
Altitude (km)	500-1600		
Inclination (deg)	Varies		

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MULTIMISSION MODULAR SPACECRAFT T-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	NA		
Storage capacity (bits)	3×10^8 2×10^4		Tape recorder
I/O rates (bps)	512 K 1024 K		STDN TDRSS (coded data); 2048 K for uncoded
Spacecraft processors/ computers	NSSC-1		
Memory size (bits)	5.76×10^5		32 K 18 bit words; expendable by factor of 2
Speed (ops/sec)			5 μsec add time
Guidance & Attitude Control			
Position accuracy (km)	±0.175		Attitude control subsystem (ACS) uses coarse & fine sensor signals, inertial reference unit (IRU), 3-axis magnetometer for initial acquisition. For other operational modes, the IRU is the principal sensor. The IRU is updated by 2 fixed head star trackers & the fine sun sensor. Payload error signals can be used in the ACS operation. Reaction wheels (20 in. oz torque, 15 ft-lb/sec) actuate, & are magnetically unloaded (10^5 pole cm) in LEO, mass expulsion unloaded in GEO.
Pointing accuracy (mrad)	0.17		1σ; down to 0.17×10^{-3} with fine sensor signals provided by a payload.
Drift (mrad/sec)	$<0.17 \times 10^{-4}$		Average rate deviation.
Attitude jitter (mrad)	$<10^{-2}$		1σ; with fine sensor signals from payload, it can be as low as 0.17×10^{-3}.
Time accuracy (parts)	10^{-6}		
Time stability (parts)	2×10^{-8}		
Type of control system	see comment		
Slew rates (mrad/sec)	0 to 3.5		Scale factor error of $1:10^4$ is achieved. Coarse slew can proceed at 30 mrad/sec.

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MULTIMISSION MODULAR SPACECRAFT T-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	0.25-1.2		Photovoltaic; 850 W maximum average available to users
Peak power consumed (kWe)	2.0		For 10 min, once per orbit
Power breakdown (We)			
Energy Storage			
Storage type			NiCd batteries; two 20 A-hr up to three 50 A-hr
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	1-64 kbps		Payload telemetry
	2.048		Maximum stored data dump rate
	2 kbps		Command rate (Shuttle/STDN): 125 or 1 kbps, selectable, through TDRSS
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			

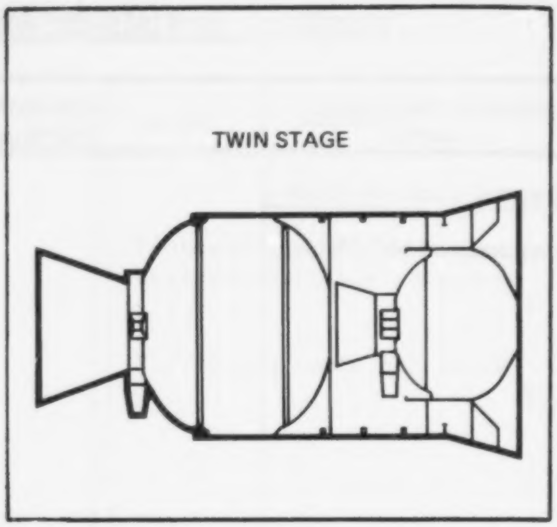
TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: MULTIMISSION MODULAR SPACECRAFT T-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			PM-I system: single-stage blowdown monopropellant hydrazine (76 kg total, 3 tanks); dry mass of 75 kg; a PM-II has been considered, using larger tanks (476 kg propellant, & 133 kg dry mass)
Total impulse (N-sec)	1.63×10^5	1, SOA	
Restarts (no.)	multiple		
Stages (no.)	NA		
Type of propellant			Hydrazine
I_{sp} of stages (sec)			
1.	220		
2.			
3.			
Thrust of stages (N)			
1.	22		Each of 4 redundant thrusters for velocity change
2.			
3.			

MISSION: INERTIAL UPPER STAGE T-8



Status: Approved

Lifetime:

Launch and Transfer Vehicles: Shuttle

Operational Location: LEO

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE:

To deliver payloads into orbits outside the operating regime of the Shuttle, using a deployable upper stage.

DESCRIPTION:

Two basic solid motors, a large and a small motor, are under development which can be combined in two and three stage configurations to satisfy the wide range of performance and interfacing requirements for DoD and NASA missions. The IUS is intended for use on high-energy missions which are beyond the capabilities of the Spinning Solid Upper Stage (SSUS) systems also under development for use with the Shuttle.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

OSTS Expendable Equipment Division (Code MXS), December 1978.

CONTACTS:

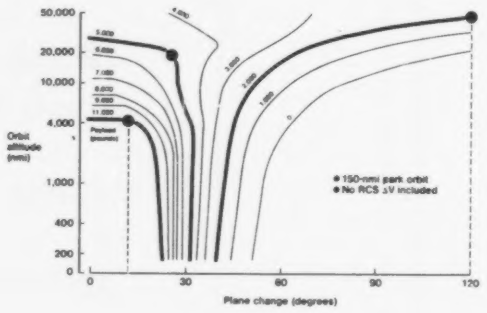
B. C. Lam, NASA HQ, MXS
J. Wild, NASA HQ, MXS
W. Tiu, MSFC

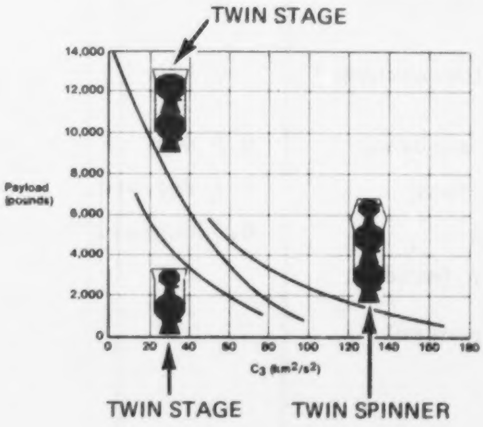
TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: INERTIAL UPPER STAGE T-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	5 6.7 8.4		Two stage Twin stage Twin spinner } Possible Configurations
Total mass (kg)	10,886 3,856		SRM-1 SRM-2
Usable propellant mass (kg)	9,707 2,722		SRM-1 SRM-2 Up to 50% of the propellant can off loaded from the SRM-1 to tailor a stage to the mission
			Two Stage - 2300 kg into equatorial geo-synch orbit from 150 nm KSC parking orbit. Second Stage accomplishes apogee injection. See Charts for other data.

TWIN STAGE





TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INERTIAL UPPER STAGE T-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Guidance & Attitude Control			
Position accuracy (km)	45		Rss error in geosynchronous orbit injection final position
Velocity accuracy (m/sec)	6.2		Rss error after completion of geosynchronous injection
Inclination accuracy (deg)	0.12		Error limit for geosynchronous injection
Pointing accuracy	0.5 deg		For each of 3 axes (attitude)
Attitude rate	0.1 deg/sec		Pitch and yaw axes
Roll rate	0.3 deg/sec		Roll axis
Stability (mrad)			
Type of control system			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: INERTIAL UPPER STAGE T-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)			
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	16 kbps Twin stage		Twin Stage 12 kbps for IUS systems 4 kbps for spacecraft
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

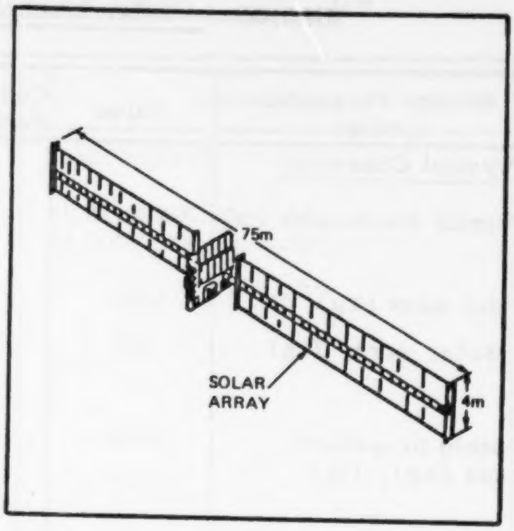
MISSION: INERTIAL UPPER STAGE T-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)	N/A		
Stages (no.)	2-3		
Type of propellant	SOLID		
I_{sp} of stages (vac)			lb_f x sec/lb_m
1.	293.3		SRM-1
2.	292.6		SRM-2
3.			
Thrust of stages (N)			
1.	1.93×10^5		SRM-1
2.	78,053		SRM-2
3.			

TRANSPORTATION

MISSION: Solar Electric Propulsion Stage (SEPS) T-9

Status:	Planned
Lifetime:	5 years
Launch and Transfer Vehicles:	Shuttle/IUS to LEO/GEO assist
Operational Location:	0.3-5.0 AU; HEO; GEO
Total Mass at Operational Location:	3400 kg (less payload)
Average Operational Power:	25 kW



OBJECTIVE:

Provide continuous low-thrust propulsion capability for near earth and planetary missions.

DESCRIPTION: The Solar Electric Propulsion Stage (SEPS) is a high-performance upper stage, consisting of an avionics module and a propulsion module, whose primary applications are interplanetary missions and support of programs around geosynchronous orbit. SEPS fits inside the Shuttle payload bay and may be boosted from the low earth orbit of the Shuttle by an IUS to avoid degrading effects on the stage solar array when passing through the Van Allen belts. The SEPS propulsion module contains 8 30-cm ion thrusters using mercury as the propellant. For trips from LEO to GEO, a IUS or a low-thrust chemical system will augment SEPS to permit payloads to be increased substantially. For exploration missions, the SEPS will be used in the range from 0.3-5.0 AU from the sun. The SEPS can also be used for moving satellites from one location to another in geosynchronous orbit in a short time (1 week or less). This capability will enable a single basic space servicing system module to be used to repair geosynchronous spacecraft.

CRITICAL TECHNOLOGY NEEDS:

None

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Solar array, avionics, thrusters

REFERENCES:

Solar Electric Propulsion System Industry Briefing, MSFC, 31 May 1979

CONTACTS:

W. Kisko, NASA Headquarters, Code MTG-3, 755-3024

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Electric Propulsion Stage (SEPS) T-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	4 × 75	2	Total array size
Total mass (kg)	3400	2	Maximum
Solar array (kg)	424	2	
Usable propellant mass (kg), (Hg)	2100	2	Maximum
Deployed items, size (m)			
1. Solar array	4 × 35.4	2, EV	Two
2. Stowed volume (m)	0.5 × 0.5 × 4.0	2	
Payload Capability			
Mass (kg)	1000	3	500-4000
Volume (m^3)			Not critical
Life			
Flight duration (days)	5 yr	2, EV	2-11 yr
Number of spacecraft	1		Frequent servicing will be required for any SEPS used as an OTV; 50 deployment/retraction cycles for solar array
Orbit			
Altitude (km)			Anywhere in the solar system from 0.3-5.0 AU, including near earth orbits
Inclination (deg)			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Electric Propulsion Stage (SEPS) T-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	25	2, SOA	31.6 kW BOL at 1 AU 25.3 KW EOL at 1 AU
Peak power consumed (kWe)			
Power breakdown (We)			
High voltage for thrusters (VDC)	1100	2, EV	
Solar cell degradation	<10%	2, EV	During transit of Van Allen belts on 90 day trip to GEO Note: Base-line calls for chemical to boost above Van Allen belts.
Energy Storage			
Storage type			NiCd batteries
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			TDRSS/STDN for earth orbital missions, DSN for planetary missions
Thermal Control			
Component temperature (K)			
1. Heat pipes	343		Maximum
2.			
3.			

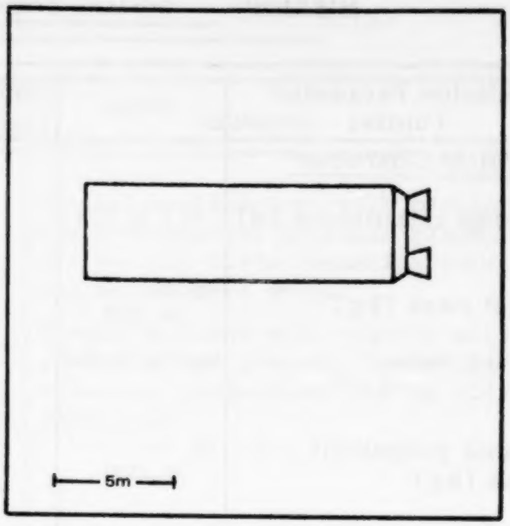
TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Solar Electric Propulsion Stage (SEPS) T-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)	6.2×10^7		Maximum, depends upon propellant loading, thrust time variable from months to years
Restarts (no.)			
Stages (no.)	NA		For near earth operations, there will be many reuses
Type of propellant	mercury	1	
I_{sp} of stages (sec)			
1.	3000	2, EV	
2.			
3.			
Thrust of stages (N)			
1.	<1	2, EV	
2.			
3.			

TRANSPORTATION

MISSION: Orbital Transfer Vehicle T-10



Status:	Planned
Lifetime:	
Launch and Transfer Vehicles:	Shuttle
Operational Location:	LEO, HEO, GEO, escape
Total Mass at Operational Location:	3 to 4 x 10^3 plus payload
Average Operational Power:	

OBJECTIVE:

Provide a large cryogenic recoverable/refurbishable transfer vehicle to place spacecraft and/or asemblies into higher energy orbits. In the 1990s carry men to GEO and return to LEO.

DESCRIPTION:

A reusable advanced LO_2/LH_2 stage occupying one shuttle bay capable of placing 8,000 kg into GEO and other payloads into various high-energy orbits including earth escape. Manned qualified to place 2/4 man crews into GEO for construction/ inspection of delivered satellites and/or assemblies.

CRITICAL TECHNOLOGY NEEDS:

Advanced LO_2/LH_2 engines may be required

Aero assisted return to LEO

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

MSFC and Contractor studies, January 1980

CONTACTS:

L. Edwards, NASA HQ, MTC-3

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Orbital Transfer Vehicle T-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	6.5 m dia		Length depends on concept. 4-10 m
Total mass (kg)	up to 28,000		Mass depends upon Shuttle capability in range of 30-45,000 kg
dry mass	up to 3,000		
Usable propellant mass (kg)	up to 25,000		
Deployed items, size (m)			
1.			Engine may be stowed to save length in payload bay
2.			
Payload Capability			
Mass (kg)	7000		To GEO (base line)
	8-9000		To GEO (with growth)
	4-5000		To GEO & return (with growth)
Life			
Flight duration (days)	0.25		One way to GEO
	14-21		Manned mission to GEO
Number of spacecraft			Depends on recovery tradeoff
Life (years)	1		Possibly longer at HEO
Orbit			
Altitude (km)	Varies		Typically used for boost/deboost between LEO and GEO
Inclination (deg)	Varies		

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Orbital Transfer Vehicle T-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			Typical applications will require state-of-the-art inertial guidance systems and basic communications for an unmanned stage. Manned versions will require more sophisticated systems, including video and rendezvous/docking aids. (See T-11)
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Orbital Transfer Vehicle T-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Requirements will depend on the application but will generally be typical of an unsophisticated upper stage. Payloads will normally provide their own power.
Average power consumed (kWe)			
Peak power consumed (kWe)			Manned versions will probably require fuel cells as part of a manned capsule.
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

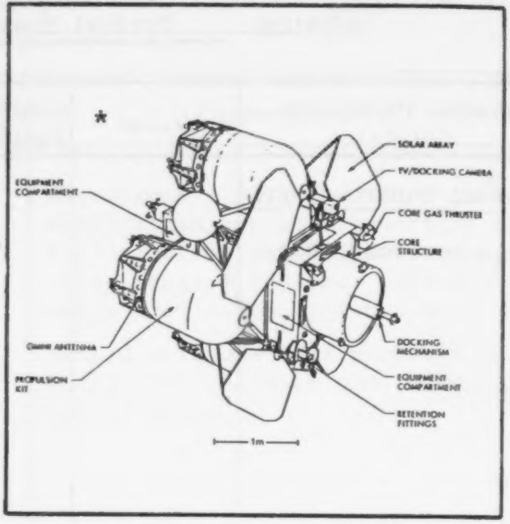
MISSION: Orbital Transfer Vehicle T-10

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			See "Usable Propellant Mass"
Restarts (no.)	3-4 25-50		Expendable missions Reusable applications
Stages (no.)	1		These stages may be combined on orbit for occasional missions requiring up to 25,000 kg payloads
Type of propellant	LO_2/LH_2		
I_{sp} of stages (sec)			
1.	460-480		Trade-offs are under way to see whether new engine development is justified. Existing RL-10 engine can probably be improved to ~460 seconds.
2.			
3.			
Thrust of stages (N)			
1.	65,000 to 85,000		Low-thrust option ~5,000 N required for some delicate payloads
2.			
3.			

MISSION: Teleoperator Maneuvering System T-11

*System concept and project name under major redefinition/review.

Status:	Candidate
Lifetime:	10 yrs with resupply and refurbishment
Launch and Transfer Vehicles:	Shuttle
Operational Location:	All STS inclinations; standoff distances from orbiter up to 1600 km
Total Mass at Operational Location:	4500 kg
Average Operational Power:	550 W



* Prior concept

OBJECTIVE:

To provide remotely manned placement and retrieval of satellites, maintenance and repair of satellites, and perform subsatellite operations.

DESCRIPTION:

The TMS core vehicle, without hydrazine performance kits, can perform all known LEO payload retrieval missions within one-half mile range of Shuttle. This includes the capability to rendezvous and dock with equipped spacecraft and return it within the Orbiter RMS range. It also enables the monitoring and viewing of free-flying spacecraft, orbiter payload bay operations, and exterior surfaces/components of the orbiter. By using 2 or 4 hydrazine or bipropellant add-on kits, the TMS can deliver and retrieve payloads to higher orbits beyond those attainable by the orbiter. With specific mission-front end kits the TMS can perform remote maintenance and repair.

CRITICAL TECHNOLOGY NEEDS: Automated Operations

INSTRUMENT OR EXPERIMENT COMPLEMENT: None

REFERENCES: R.F. Molly, J.R. Tewell, R.A. Spenser, Teleoperator Retrieval System; Earth Orbital Teleoperator Systems, Concepts, and Analysis, Martin Marietta Corp. for MSF, Contract NAS8-31290, Vol. 1-5, May 1976; Integrated Orbital Sensing Study for Low Cost Payload Program, Martin Marietta Corp. for MSFC, Contract NAS8-30820, Vol. 1-2, Sept. 1975; Integrated Orbital Servising Study Follow-On, Martin Marietta Corp. for MSFC, Contract NAS8-30820, Vol. 1-3, June 1978.

CONTACTS: W. Smith, NASA HQ, MTG-3

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Teleoperator Maneuvering System T-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	3.3 x 3.2 x 3.4		LWH
Total mass (kg)	5600-6500		4 tank configuration
Basic core (dry)	640-850		
Usable propellant mass (kg)	3600-4000		
Deployed items, size (m)			
1. Manipulator	4.6		
2.			
Payload Capability			
Mass (kg)	TBD		
Volume (m^3)	NA		Will be defined by largest S/C placement & return (retrieval) requirements.
Life			
Flight duration (days)	TBD		10 years total with resupply and refurbishment
Number of spacecraft	TBD		
Orbit			
Altitude (km)	1000		Stand-off altitude from orbiter
Inclination (deg)	28.5-polar		
Operational range (km)	500-40,000		RF Link limit: 556 km

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Teleoperator Maneuvering System T-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	TBD		
Storage capacity (bits)	TBD		
I/O rates (bps)	TBD		
Spacecraft processors/ computers	TBD		
I/O rates (bps)	TBD		
Memory size (bits)	TBD		
Speed (ops/sec)	TBD		
Ground processors/ computers	TBD		
Memory size (bits)	TBD		
Guidance & Attitude Control			3-axis reference system
Position accuracy (km)			
Pointing accuracy (mrad)	4.4		
Stability (mrad)	1.7		per sec
Type of control system			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Teleoperator Maneuvering System T-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	TBD		
Peak power consumed (kWe)	TBD		
Power breakdown (We)	TBD		
Energy Storage			
Storage type	NiCd batteries		Batteries need recharging every 20 hours
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TBD		
Thermal Control			
Component temperature (K)	TBD		
1.			
2.			
3.			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

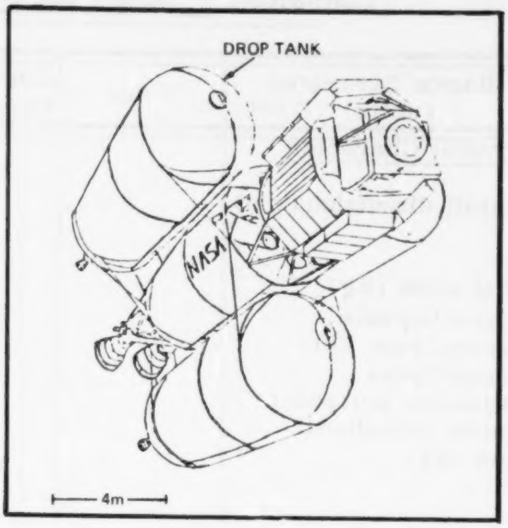
MISSION: Teleoperator Maneuvering System T-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)	TBD		
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)	TBD		
Restarts (no.)	TBD		
Stages (no.)	TBD		
Type of propellant			Hydrazine or bi-propellant
I_{sp} of stages (sec)	TBD		
1.			
2.			
3.			
Thrust of stages (N)	TBD		
1.			
2.			
3.			

TRANSPORTATION

MISSION: Manned GEO Sortie T-12

Status:	Candidate
Lifetime:	
Launch and Transfer Vehicles:	Shuttle
Operational Location:	370 km for assembly/ GEO for utilization
Total Mass at Operational Location:	5000-6000 kg
Average Operational Power:	



OBJECTIVE:

A man rated orbital transfer vehicle primarily to be used for service of spacecraft at GEO.

DESCRIPTION:

The vehicle is comprised of a crew capsule, which houses the crew and mounts external cargo and mission equipment, and a propulsion module. The MOTV is capable of deploying and returning the manned capsule and 1-2,000 kg of servicing equipment.

CRITICAL TECHNOLOGY NEEDS:

Aero assisted return from LEO; manipulators.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

Manned Geosynchronous Mission Requirements and Systems Analysis Study, Grumman Aerospace Corporation for JSC, Vol. 1-6, 7 November 1979 and OTV contractor studies.

CONTACTS:

L. Edwards, NASA HQ, MTC-3

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Manned GEO Sortie

T- 12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			Studies in 1979 defined an ambitious mission requiring four shuttle flights to send a single capsule to GEO and return with propulsive braking. It is evident that aero-assisted braking at LEO can permit more realistic missions with two shuttle launches. With a 100 K pound shuttle, it is possible that useful missions with a single STS launch will be possible. Investigations are under way as of April 1980.
Total mass (kg)			
Crew Capsule			
Propulsion Core			
Drop Tanks			
Mission Equipment			
Usable propellant mass (kg)			
Deployed items, size (m)			
1. Grappler			
2. Capsule (m^3)			
3. Solar array (m^3)			
Payload Capability			
Mass (kg)			
Volume (m^3)			
Life			
Flight duration (days)			
Number of spacecraft			
Mission Life (yrs)			
Radiation dose			
Orbit			
Altitude (km)			
Inclination (deg)			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Manned GEO Sortie T-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			Star scanners
			Inertial measuring unit (IMU)
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

TRANSPORTATION
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Manned GEO Sortie T-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control (Cont.)			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total impulse (N-sec)			
Restarts (no.)			
Stages (no.)			
Type of propellant	LO_2/LH_2		Trade-offs are under way to see whether new engine development is justified. Existing RL-10 engine can probably be improved to ~460 seconds.
I_{sp} of stages (sec)			
1.	460-480		
2.			
3.			
Thrust of stages (N)			
1.			
2.			
3.			

TRANSPORTATION

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Manned GEO Sortie T-12

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)			Fuel cell/photovoltaic
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type	Batteries		
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TDRSS/Shuttle TV/Digital		
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			

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UTILIZATION OF THE SPACE ENVIRONMENT

The Utilization of the Space Environment program objectives include research and experimentation in materials processing and space biology, space industrialization, space power, platforms, and nonterrestrial materials utilization. The near-term emphasis is on initiation of Spacelab and free-flier missions to develop the complex space systems and operations required for exploiting the characteristics of space, such as weightlessness and ultrahigh vacuum. The far-term emphasis will be on commercial scale operations in earth orbit and perhaps in the lunar vicinity.

Utilization of the Space Environment Missions

NO.

U-1 National Materials Laboratory program will provide opportunities for scientific and commercial users to exploit the space environment to perform experiments in materials processing.

U-2 Spacelab is to provide early access to space for a broad spectrum of experimenters.

U-3 Extraterrestrial Materials Processing program will develop and demonstrate techniques for extracting materials from nonterrestrial bodies and processing them into useful components.

U-4 Tethered Satellite System will perform in situ studies down to 100-120 km altitudes of magnetic and gravitational fields, space plasma, and may be used in various other applications.

U-5 Large Space Structures Technology and Development program will provide the tools, techniques, and operations needed to use the Shuttle for a broad range of orbital construction operations.

U-6 Power Extension Package provides additional on-orbit power to enable longer Shuttle flights.

U-7 Science and Applications Space Platform is a permanent operational base and laboratory to support several missions.

U-8 25-kW Power System provides electric power, attitude control, and heat rejection for the STS orbiter in the sortie mode.

U-9 Materials Experimentation Carrier is intended to provide the capability to support large numbers of materials research experiments.

U-10 Materials Experimentation Carrier II will provide a follow-on capability for materials processing after the five years of MEC research.

U-11 Large Power Module is a large modularized expandable power module to support power intensive activities in space.

UTILIZATION OF SPACE ENVIRONMENT

MISSION: National Materials Laboratory U-1

Status: Approved

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE: The development of a unique national laboratory to pursue the goals of a maturing materials processing in space (MPS) program. This shall be a space-based facility whose principal systems and experiments will be logical extensions of currently planned systems and experiments.

DESCRIPTION: The description and utility of this facility will be resolved as the MPS goals of user organizations mature and become more focused.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT: Solidification Experiment System, High Gradient Furnace System, Acoustic Containerless Processing Module, Electromagnetic Containerless Processing System, Biological Processing System, Analytical Floating Zone System, Isoelectric Focusing System

REFERENCES:

FY 1980-84 NASA Five-Year Plan

CONTACTS:

J. Carruthers, NASA HQ, EM-7

MISSION: Spacelab U-2

Status: Approved

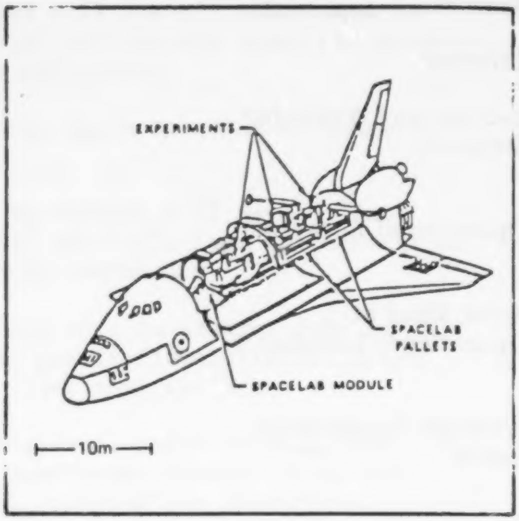
Lifetime: 5-20 flights annually

Launch and Transfer Vehicles: Shuttle

Operational Location: LEO

Total Mass at Operational Location: 6200 kg

Average Operational Power: 4 kW



OBJECTIVE:

The purpose of Spacelab is to provide ready access to space for a broad spectrum of experimenters in many fields and from many nations. Low-cost techniques are envisaged for experiment development, integration, and operation.

DESCRIPTION:

Spacelab is an orbital facility that provides a pressurized, "shirt sleeve" laboratory (the module) and an unpressurized platform (the pallet), together with certain standard services. It is a reusable system. As part of the Space Transporting System (STS), it is transported to and from orbit in the cargo bay of the Space Shuttle Orbiter and remains there throughout the flight. Spacelab extends the Shuttle capability, and the Orbiter/Spacelab combination can be regarded as a short-stay space station which can remain in orbit initially for up to 12 days and eventually up to 30 days (the nominal mission duration is 7 days). In orbit, the experiments carried by Spacelab are operated by a team of up to four payload specialists who work in the laboratory but spend their off-duty time in the Orbiter cabin.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

Spacelab Mission 1 Experiment Descriptions, MSFC, NASA TM-78173, May 1978; Spacelab Mission 2 Experiment Descriptions, MSFC, NASA TM-78198, September 1978; Spacelab User's Guide, Issue No. 2, ESA SP-1001, May 1978.

CONTACTS:

Ed James, NASA HQ, Code MSF-5

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	7 x 4.1		L,D
Total mass (kg)	4800-9400		Depends upon configuration, etc.
Pressurized dimensions (m)	7 x 4.1		L,D
Deployed items, size (m)			
1. Pallet segment	2.9		Up to 5 accommodated in Shuttle bay
2.			
Pallet volume (m^3)	100-160		
Experiment volume (m^3)	8-22		
Pallet mounting area (m^2)	51 85		Independently suspended pallet 15-m pallet
Life			
Flight duration (days)	7-30		
Number of spacecraft			
Time between launches (days)	18-73		5-20 flights annually
Orbit			
Altitude (km)	200-900		
Inclination (deg)	28.5-57 up to 104		KSC launch Vandenburg launch

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	3×10^9 - 3×10^{10}		
Storage capacity (bits)	3×10^9 - 3×10^{10}		Tape recorder
I/O rates (bps)	1-30 M		
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)	1 M		16 bit words, 0.25 M to user
Speed (ops/sec)	350,000		
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			Shuttle parameters
Position accuracy (km)			
Pointing accuracy (mrad)	8.7		1 axis
Stability (mrad)			
Type of control system			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	2.5-5.5		Fuel cell
Peak power consumed (kWe)	8-9		
Electrical Power	28 (VDC)		
High voltage (VAC)	115/200		@400 Hz
Energy Storage			
Storage type			
Energy/cycle (J)			
Total energy (kWh)	250-550		
Communications			
Link, type of data and rate (Mbps)	Orbiter up to 50		
Special			
g-limits	3 10^{-4}		Ascent/descent In orbit
Acoustic noise (dB)	145 136		Launch/cargo bay Launch/module
Vibration (g's)	4		RMS random

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Equipment (module)	293-313		
2. Cabin air	291-300		
3. Cold plate (module)	283-313		
4. Cold plate (pallet)	283-313		
Component load (Wt)			
1. Cold plate (module)	4000		
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	NA		
Thrust level (N)			
I_{sp} of stages (sec)			

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab U-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Imaging Spectrometer Observatory (SL-1)	Air Glow Spectrum Range: 20-1200 nm Resolution: 0.2-0.6 nm		FOV: 0.5° × 0.007°; 5 identical spectrometers
Atmospheric Trace Molecule Spectroscopy (ATMOS) (SL-1)	Upper Atmospheric Structure Range: 2-16 μm Spectral Resolution: 0.02 cm^{-1}		Continuous scan Fourier spectrometer
Grille Spectrometer (SL-1)	Atmospheric Trace Species Range: 2.5-13 μm		3-m telescope
Temperature & Wind in Mesosphere & Thermosphere (SL-1)		Vertical resolution: 2 km; thermospheric air glow spectrum: 557.7, 630.0, 731.9 nm; mesospheric spectrum: 557.7, 730.0 nm	0.2-m diameter Cassegrain; HFOV: 2° diameter; VFOV: 0.1° mesospheric; 0.4° thermospheric. Michelson interferometer
Waves in the OH Emissive Layer (SL-1)	Wave Structure Size: 40-1000 km Velocities: <20 m/s Contrast:		16-mm movie camera with image intensifier
Investigation of Atmospheric H&D Through the Measurement of Their Lyman-α Emissions (SL-1)		Vertical range: 90-250 km	Spectrophotometer with 2 absorption cells (1 hydrogen, 1 deuterium)
Metric Camera Experiment (SL-1)	Topographic Mapping Resolution: <20 m		RMK 30/20 mapping camera
Microwave Remote Sensing Experiment (MRSE) (SL-1)	Ocean Surface Wave Spectra Components: 10-500 m		2 frequency scatterometer
	Sea Ice, Oil Slicks, & Land Mass Resolution: 25 × 25 m		SAR
	Temperature Sounding Ocean surface temperature:		Passive microwave radiometer

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab U-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Space Experiments with Particle Accelerators (SEPAC) (SL-1)	Vehicle charge neutralization; beam plasma physics; beam atmosphere physics	Electron Beam Accelerator Voltage: 1-7.5 kV Pulse width: 10 ms - 1 s MPD Arc Jet (Argon) Input energy: 2 kJ/pulse	
Low Energy Electron-Flux & Its Reaction to Active Experimentation on Spacelab (SL-1)	Parallel Electric Field Electron flux energy range: 0.1-12 keV		FOV: ~2π sr. Continuous channel electron multiplier.
DC-Magnetic Field Vector Measurement (SL-1)	Magnetic field		3 independent flux gate magnetometers
Isotopic Stack (SL-1)	Cosmic Ray Measurements $Z \geq 3$; particle spectra: 20-100 MeV/amu; cosmic ray spectra: 100-1000 MeV/amu		Mass: 20 kg; dimensions: 50 cm, 7 cm; FOV: 2π sr. Diameter, height, plastic visual track, detector sheets (cellulose nitrate & Lexan polycarbonate)
Charged Particle Beams (SL-1)	Geo-electric field, aurora, etc.; charge neutralization return current; AC Magnetic Field: frequency: 200 Hz; Electric Fields: frequency: 100 MHz	Electron Gun Current: 0.1 amp Energy: ≤10 keV Ion Gun Current: 10 m amp Energy: ≤10 keV	

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Atmospheric Emission Photometric Imaging (SL-1)	Ionospheric Transport Spectral range: 279.5-280.2 nm; 247.0 nm; 731.9 nm		LLLTV; Mg^+, O^+
Ionization States of Solar & Galactic Cosmic Ray Heavy Nuclei (SL-1)	Low Energy Cosmic Rays Range: 5-100 MeV/amu		Size: 40-cm diameter, 25-cm height; rotation rate: 0.019 mrad/s. Species: C, N, O, Ne, Ca to F_e; steps of 0.02 mrad every 10 s.
Far Ultraviolet Space Telescope (FAUST) (SL-1)	Observation of UV stars, galaxies, quasars	Spectral range: 110-200 nm Image resolution: 1.16 mrad	Wayne Camera: F: 1.12; aperture: 150 cm^2; FOV: 0.13 rad Overall Size: diameter: 48.8 cm, length: 131.3 cm
Very Wide Field Camera (SL-1)	Wide field photography in the near ultraviolet	Spectral range: 130-270 nm Resolution: 0.5-0.8 nm	Schmidt Camera: FOV: 0.943 rad
Astronomical X-Ray Spectroscopy (SL-1)	Energy: 0.1-30 keV Resolution: 10% at FWHM		Gas scintillation proportional counter
Active Cavity Radiometer Irradiance Monitor (SL-1)	Total Solar Irradiance Resolution: ±0.1%		FOV: 0.175 rad
Measurement of Solar Constant (SL-1)	Solar Flux Accuracy: ±1.4 W/m^2 Sensitivity: 0.7 W/m^2		FOV: 0.88π sr; LWH: 160 × 156 × 434 mm. 2 independent radiometers.
Solar Spectroscopy (SL-1)	Solar Spectra Range: 170-3200 nm	UV: 170-370 nm; V: 350-900 nm; IR: 800-3200 nm	Calibration lamps 2 spectrometers

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Ejectable Plasma Diagnostics Package (PDP) (SL-2)	Low Energy Protons & Electrons Energy range: 2 eV - 50 keV Electromagnetic, Electrostatic Fields Frequency components: 5 Hz - 30 MHz dc Electric Fields Range: 2-2000 mV/m dc Magnetic Fields Electron Density Range: 10^4-10^7 cm^{-3} Electron Temperature Range: 500-5000 K Plasma Ions Energy: <16 eV Density: 10^2-10^7 cm^{-3} Temperature: 500-10^6 K Velocity: ≤15 km/s Ion Mass Range: 1-64 amu Density: 20 - 2 × 10^6 cm^3		Dimensions PDP: 107 × 93 cm; special purpose end reflector: 81 × 35 cm; release mechanism: 120 × 142 × 16 cm; RF antenna assembly: 40 × 40 × 80 cm; receiver & data processing box: 30 × 50 × 20 cm; total mass: 395 kg; average power: 50 W; total energy: 2.04 kWh. PDP is a fully instrumented ejectable subsatellite. Quadspherical differential analyzer; plasma wave analyzer/electric dipole & magnetic search coil sensor; dc electric field meter; triaxial flux gate magnetometer; Langmuir probe; retarding potential analyzer & differential flux analyzer. Data Rates Digital: 337 kbps Video: 4.2 MHz Mass spectrometer
Plasma Depletion Experiments for Ionospheric & Radio Astronomical Studies (SL-2)	Ionosphere hole measurements; electron concentrations; plasma drift; electron temperature		This is a ground-based experiment using selected Shuttle OMS kit firings, 150-ft ground antenna, and geostationary satellite RF signals.

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Small Helium Cooled Infrared Telescope (SL-2) He-IRT	Low-Surface Brightness Infrared Emissions Sensitivity: 2 × 10^{-14} W/cm^2/sr Diffuse IR Emissions Zodiacal Dust Emission Spectral range: 4-120 μm		250 liter super filtered He dewar Herschelian Optics Off-axis parabolic mirror; diameter: 15 cm; f stop: f/4; scan rate: 0.21 mrad/s; dimensions: 165 × 91 × 340 cm; total mass: 690 kg; average power: 125 W; total energy: 25 kWh; data rate: 614 kbps
Composition & Energy Spectra of Cosmic Ray Nuclei (SL-2)	Energy Spectra Range: 50 GeV - 3 TeV per nucleon		Gas Cerenkov counters (2); scintillator (2); radiators (6) - plastic foils, 5 μm thick (10,000); Xenon filled multiwire proportional chambers (6) Dimensions Detector assembly: 280 × 280 × 370 cm; support structure: TBD; total mass: 1784 kg; average power: 231 W; total energy: 44 kWh; data rate: 102 kbps
Hard X-Ray Imaging (SL-2)	Spatial & Spectral Distribution of X-Ray Flux Energy: 2-20 keV	Pointing accuracy: 8.7 mrad	Coded binary mask position - sensitive sensor (proportional counters) Dimensions Telescopes: 206 × 335 × 100 cm; electronics: 60 × 30 × 30 cm; total mass: 326 kg; average power: 160 W; total energy: 30 kWh; data rate: 62 kbps. Uses a variation of Dicke random pinhole mask technique.

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab U-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Solar Optical Universal Polarimeter (SOUP) (SL-2)	Continuum & line center brightness; equivalent linewidth; Doppler velocity; magnetic field strength; magnetic flux	Spectral bandwidth: 8 Å Wavelength steps: 2 mÅ	Birefringent filter bandpass 60 mÅ; CID array camera; 30-cm Cassegrain; telescope video; processor **Dimensions** Telescopic & focal plane structure: 40 × 40 × 205 cm; processor: 56 × 48 × 36 cm; total mass: 183 kg; average power: 322 W; total energy: 31.7 kWh **Pointing Requirements** Accuracy: 0.048 mrad; stability: 2.4×10^{-4} mrad/0.33 s **Data Rate** Digital: 3 Mbps; video: 4.2 MHz Requires IPS
Coronal Helium Abundance Spacelab Experiment (CHASE) (SL-2)	Relative abundance of HE to H **Coronal Plasma** Electron density; temperature balance; ionization EUV spectral map	Concave grating line resolution: 1200 lines/mm	Wolter type I sector; design 28-cm focal; length grazing; incidence telescope 1-m grazing incidence spectrometer **Dimensions** CHASE instrument: 56 × 61 × 119 cm; electronics: 30 × 30 × 30 cm; total mass: 160 kg; average power: 80 W; total energy: 8.9 kWh **Pointing Requirements** Accuracy: 0.073 mrad; stability: 0.024 mrad; data rate: 8.2 kbps

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab U-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
High-Resolution Telescope & Spectrograph (HRTS) (SL-2)	Line intensity measurements; Doppler measurements; line profile analysis UV Spectra Spatial resolution: 4.8 × 10^{-3} mrad; spectral resolution: 0.05 Å; wavelength: 1176-1700Å	Spectral resolution: 50 mÅ; spatial resolution: 4.8 × 10^{-3} mrad; band pass: 35 Å (FWHM); spatial resolution: 4.8 × 10^{-3} mrad	Concentric Gregorian telescope; primary mirror diameter: 300 mm paraboloid Requires IPS Focal length: 900 mm; FOV: 2.1 × 4.4 mrad (effective); symmetric tandem; Wadsworth UV spectrograph; 1600 Å broadband spectroheliograph; FOV: 1.5 × 4.4 mrad; Hα filter; 2 tandem Fabry Perot interference filters; hW: 0.5 Å; MINSIT camera Dimensions HRTS cannister: 49 × 340 cm; electronic: 49 × 60 cm; total mass: 184 kg; average power: 340 W; total energy: 48.6 kWh Pointing Requirements Accuracy: 0.29 mrad; stability: 4.8 × 10^{-3} mrad Data Rates Digital: 5.1 kpbs; video: 4.2 MHz
Solar UV Spectral Irradiance Monitor (SUSIM) (SL-2)	Solar Continuum Irradiance Wavelength: 120-400 nm; accuracy: ±6-10%	Spectral resolution: 0.1 nm	Requires IPS D_2 calibration lamp; double dispersion; scanning spectrometer; photodiodes (5); photocounters (2) Dimensions: 23 × 35 × 77 cm; total mass: 50 kg; average power: 53 W; total energy: 6.3 kWh Pointing Requirements Accuracy: 8.7 mrad; stability: 1.7 mrad; data rate: 0.1 kbps

UTILIZATION OF SPACE ENVIRONMENT
SENSOR/EXPERIMENT PARAMETERS

MISSION: Spacelab U-2

Sensor or Experiment Name	Physical Property Measured/Property Range & Accuracy Resolution	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
MESA Low-G Accelerometer (SL-2)	Acceleration Range: 10^{-8}-10^{-4} g		Dimensions Accelerometer table assembly: 25 × 16 cm; electronic: 21 × 13 × 9 cm; total mass: 8 kg; average power: 20 W; total energy: 3.8 kWh; data rate: 0.1 kbps MESA (proof mass miniature electrostatic accelerometer)
Properties of Superfluid Helium in Zero G (SL-2)	Low Frequency Slosh Modes Microkelvin Temperature Fluctuations Frequency: 0-100 Hz; Surface wave velocity Surface Attentuation Range: 0.1-1 m	Temperature resolution: 10 μk; temperature sensitivity: 1 mk	90-ℓ superfluid helium toroidal cryostat; liquid vapor sensors (100); 3-liter work space; semiconductor thermal sensors; carbon film detections Dimensions Cryostat: 100 × 100 cm; experiment processor: 45 × 17 × 23 cm; vacuum pump: 30 × 30 × 45 cm; total mass: 205 kg; average power: 60 W; total energy: 11.3 kWh; data rate: 20 kbps

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Sensor or Experiment Name	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Isothermal Heating Facility		Experiments Using IHF Solidification of immiscible alloys; emulsions and disperson alloys; reaction kinetics in glass; skin technology; vacuum brazing; solidification of technical alloys; composites (He-glass); metallic emulsions AlPb; bubble reinforced materials; nucleation behavior of Ag-Ge; dendrite growth and macrosegregation; fibre and particle composites; composites with short fibres and particles; solification of near monotectic ZnPb alloys
Operating temperature (K)	473-1873	
Temperature accuracy (K)	±5, ±10 (573 K, 1773 K)	
Isothermal zone dimensions	100 mm × 40 mm (L, D)	
Temperature grad (K/cm)	0.5	
Pressure (Pascals) (SL-1)	$10^{-2} - 1.2 \times 10^{5}$	
Gradient Heating Furnace I		Experiments Using GHF-I Unidirectional solidification of Al-Zn, Al-Al_2Cu, Ag-Ge eutectics; growth of lead telluride; unidirection solification of eutectics (InSb-NiSb); thermodiffusion in tin alloys
Temperature (K) (max)	1473	
Gradient (K/cm)	≤100	
Heating rate (hr) (max)	1.5 (to 1473 K)	
Cooling rate (hr) (SL-1)	4-20 (from 1473 to 323 K)	
Mirror Heating Facility		Experiments Using MHF Zone crystallization of silicon; traveling solvent growth of CdTe; traveling heating method of III-V compounds (InSb); crystallization of silicon spheres; unidirectional solidification of cast iron
Maximum sample diameter (mm)	20	
Zone length (mm)	10-20	
Turn velocity (rad/min)	0.1-10	
Feed velocity (mm/min)	10^{-3}-10	
Operating temperature (K) (SL-1)	473-2373	

MISSION: Spacelab U-2

Sensor or Experiment Name	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Mirror Heating Facility (Cont.)		
Temperature accuracy (K)	±5	
Operating pressure (Pascals) (SL-1)	$10^{-2} - 1.2 \times 10^{5}$	
Fluid Physics Module		Experiments Using FPM Oscillation damping of a liquid in natural levitation; kinetics of spreading liquids on solids; free convection in low gravity; capillary surfaces in low gravity; coupled motion of liquid-solid systems in near-zero gravity; floating zone stability in zero gravity
Test zone (mm)	130 × 100 (height, diameter)	
Rotation speeds (rpm)	5-100 (±1%)	
Injection speed (cm^3/s)	0.5-6.0	
Capacity (ℓ)	1.3	
Oscillations (Hz, mm)	0.1-2.0; 0.05-0.5	
Temperature (K)	≤333	
Electrical potential (VdC) (SL-1)	±100	
Special Equipment for Experiments (SL-1)		Interfacial instability and capillary hysteresis; adhesion of metals UHV chamber; growth of manganese carbonate; organic crystal growth; self- and inter-diffusion in liquid metals; crystal growth in proteins; growth of HgJ_2 single crystals; wetting, spreading, and operating characteristics of bearing lubricants in low-g environment; geophysical fluid flow experiment

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Spacelab U-2

Sensor or Experiment Name	Associated Ranges and/or Resolutions	Purpose, Component Properties, Other Comments
Space Sled Vestibular Facility		Experiments Using SSVF Effects of rectilinear evaluations, opto-kinetic and caloric stimulations in space; vestibular experiments; vestibulo-spinal reflex mechanisms
Acceleration (g's) (SL-1)	0.001-0.2	
Life Sciences		Experiments The influence of spaceflight on erythrokinetics in mass; measurement of central venous pressure and determineation of hormones in blood serum during weightlessness; effects of prolonged weightlessness on the humoral immense response of humans; effect of weightlessness on lymphoyte proliferation; three-dimensional ballistoradiography in weightlessness; personal miniature electrophysiological tape recorder; mass discrimination during weightlessness; nutation of *helianthus annus* in a microgravity environment; preliminary characterization of persisting circadian rhythms during spaceflights - *neurospora* as a model system; macro-organisms and biomolecules in hand space environment; advanced biostack experiment; radiation environment mapping; vitamin D metabolism and bone demineralization; the integration of oxygen and gravity influenced lignification
Size (cm)	30 × 20 × 8 [blood collection kits (2)] 47 × 39 × 23 (centrifuge) 53 × 56 × 46 (freezer)	
Total mass (kg)	46	
Average power (W)	200	
Total energy (kWh)	0.3	
Size (cm)	51 × 36 × 27	
Total mass (kg)	25	
Average power (W)	55	
Total energy (kWh) (SL-1, SL-2)	12	

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Extraterrestrial Materials Processing U-3

Status: Approved

Lifetime:

Launch and Transfer Vehicles: NA

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE:

The Extraterrestrial Materials Processing program will develop and demonstrate techniques for extracting metals and other useful materials from minerals of the types found on the moon, planets, and asteroids and processing them into components for operational space systems. The extractive and fabrication processes will be compatible with automated, remote operations with no supplies furnished from earth, and the demonstration will be entirely automated. One of the long-range goals of this activity is to provide a materials technology that could be employed by an automated, self-replicating system planted on some extraterrestrial body.

DESCRIPTION:

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

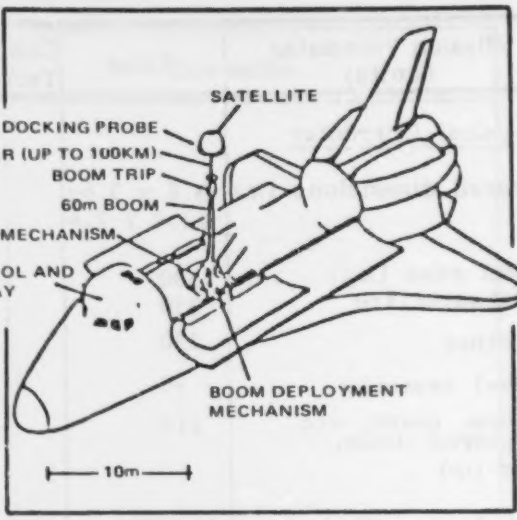
CONTACTS:

J. Carruthers, NASA HQ, EM-7

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Tethered Satellite System U-4

Status:	Planned
Lifetime:	1.5-6.5 days of data acquisition
Launch and Transfer Vehicles:	Shuttle
Operational Location:	LEO
Total Mass at Operational Location:	1500 kg
Average Operational Power:	150 W



OBJECTIVE: To permit in situ studies (down to altitudes of about 120 to 100 km) of magnetics and gravitational fields; lower thermosphere and mesosphere space plasma studies; generation of electrical power and prototype "space crane."

DESCRIPTION: The Tethered Satellite System deploys a subsatellite from the Shuttle, exploiting gravity gradient forces. The system would have a total mass up to 1500 kg and could be mounted on one Shuttle pallet. It would consist of a tether reel mechanism with a servo drive motor and control sensors, a boom with docking probe used for initial deployment and subsequent retrieval, some type of satellite weighting 350 kg, up to 100 km of synthetic or metallic tether approximately 1 mm in diameter, a digital control computer, and a control and display panel on the Orbiter aft flight deck for crew operation.

CRITICAL TECHNOLOGY NEEDS:

None.

INSTRUMENT OR EXPERIMENT COMPLEMENT: Varies with each mission. Typical candidates are: magnetometer, gradiometers, "dumb bell" proof masses, atmospheric instruments, chemical release equipment, ELF/ULF antenna derived from atmospheric explorer satellites.

REFERENCES: Shuttle/Tethered Satellite System, C. C. Rapp & J. H. Lane, Proceedings of the 1978 Goddard Memorial Symposium, 3/78, No. 78-048; W. C. Snoddy, Scientific & Technical Applications of a Tethered Satellite System, A79-19503; G. Colombo, E. M. Gaposchkin, M. D. Grossi, G. C. Weiffenbach, Long Tethered Satellite for the Shuttle Orbiter, A76-42254, and Gravity-Gradient Measurements Down to ~100-km Height by Means of Long-Tethered Satellites, A76-46042.

CONTACTS: E. J. Brazill, NASA HQ, MTG-3, 755-3024

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tethered Satellite System U-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	3.8 x 3.6-12.4 x 2.4		LWH
Total mass (kg)	1500		
Subsatellite	350		
Tether	250	2, EV	
Reel assembly	90	2, SOA	
Boom, power, etc.	810	2, SOA	
Deployed items, size (m)			
1. Tether (km)	10-100	1, EV	
2. Boom (m)	20-50		Extendable
Reel velocity (km/hr)	10-20	2, EV	
Life			
Flight duration (days)	1.5-6.5		Mission length
Number of spacecraft			
Orbit			
Altitude (km)	100		Relative to shuttle orbit
Inclination (deg)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tethered Satellite System U-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	TBD		
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground Processors/ computers			NASA standard spacecraft computer
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)	N/A		
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tethered Satellite System U-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	.121		Fuel cell
Peak power consumed (kWe)	1.128		
Power breakdown (We)			
Energy Storage			
Storage type	N/A		
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TBD		

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Tethered Satellite System U-4

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			Tether and subsatellite must be able to reject temperatures of up to 870° C
1.			
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	N/A		
Thrust level (N)			
I_{sp} of stages (sec)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Large Space Structures Technology and Development Program U-5

Status: Planned

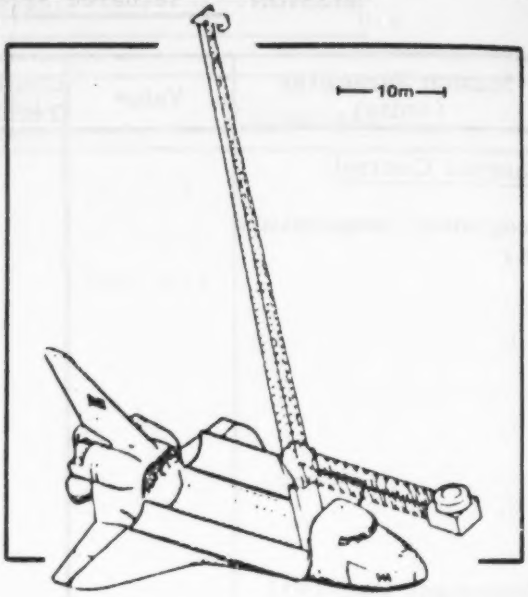
Lifetime:

Launch and Transfer Vehicles: Shuttle

Operational Location:

Total Mass at Operational Location:

Average Operational Power:



OBJECTIVE:

Lower the technological risk of large space structures to the point of likely user acceptance. Prove the tools, techniques, and operations needed to use the Shuttle for a broad range of orbital construction operations.

DESCRIPTION:

The strawman program in the reference report leads to flight tests of those structural elements needed for the large structures of interest to potential users. Further definition of the tasks required to complete the program is in progress by a continuation of the Task Team effort. The current version of the plan is phased in objectives and funding. Its elements are outlined on the following pages.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

I. Bekey, Large Space Structures Technology and Development Program, Report of Large Structures Technology and Development Task Team, 21 September 1979.

CONTACTS:

I.Bekey, NASA HQ, Code MTC-3

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Large Space Structures Technology and Development Program U-5

DESCRIPTION (Cont.):

PHASE 1 (Ground Tests)

High Stiffness Truss Structures
Components static and dynamic tests; timeliness development; EVA tools and techniques development; deployment concept tests.

Low Stiffness Large Planar Substructures
Cap forming test; welding test; brass board beam builder test; jigs and figures tests; beam static and dynamic characterization.

Precision/Shaped Structures
5-m and 20-m scale models; thermal/dynamic distortions; deployment concept verify; component characterization.

PHASE 2

Program in High Stiffness Trusses: Deployment and Erection Experiments
Determine damping, thermal, static, and dynamic characteristics of beams and joints in space environment; validate deployment kinematics; verify timeliner; verify analytical predictions and ground tests.

Program in Low Stiffness Planar Substructures: Tests of Beam Machine Components
Cap forming, roll trusion, process; ultrasonic weld optimization; materials evaluation in environment; return specimens in vacuum containers; verify/evaluate ground tests.

Program in Precision/Shaped Surfaces: Mast and Membrane Sections
Determine static, thermal, and dynamic properties of precision boom; determine zero "0" joint damping; validate controlled deployment technique; retract, return all materials for ground analysis.

PHASE 3

Program in High Stiffness Structures: 10-m Truss
Static/thermal dimensional stability; dynamic damping/vibration modes; deployment/erection control; initial structures/control interaction; mounting/construction jigs and fixtures.

Program in Low Stiffness Planar Substructures: Single Fabricated Beam
Test automated beam and builder; evaluate static, thermal, dynamic properties of beam; investigate flexible structure control/dynamics interaction; return product (or parts) for examination.

Program in Precision/Shaped Structures: Precision Mast Deployment
Evaluate controlled deployment mechanism; evaluate static, thermal, and dynamic dimensional stability of structure; evaluate structure dynamic modes.

MISSION: Large Space Structures Technology and Development Program U-5

DESCRIPTION (Cont.)

PHASE 4

Program in High Stiffness Structures: 50-m Truss
Propagation of modes/damping/dynamics in multijointed truss; static load/thermal properties; berthing jigs and figures; control/structures interaction; zero "0" math model verification.

Program in Low Stiffness Planar Arrays: 100-m Substructure Truss
Dynamic and static behavior of very large area low stiffness structures; distributed control model verification; evaluation of jigs and fixtures; construction/assembly techniques for large area structures.

Program in Large Volumetric Fabricated Structures: 30-m Tri-Beam
Determination of static, thermal, and dynamic properties of fabricated tri-beams; verification of math models; determination of damping properties and dynamic modes; verification of fabrication and assembly jigs and fixtures.

Program in Precision/Shaped Structures: Antenna Deployment
Dynamic, thermal, static performance of large, precision shaped surfaces/feeds; verification of analytical performance models; furl/refurl of shaped surfaces in constrained dynamics; characterization of zero and damping factors.

PHASE 5

Program in High Stiffness Structures: 50-m Free Truss
Gravity gradient stabilized; >1-yr life at higher orbit (attained by Shuttle OMS prior to release); docking adapter for TRS-type vehicle visits; self-contained instrumentation/telemetry/battery package; long-term space structures test/evaluation; could become part of permanent structures test facility; measure modal responses and damping free from orbiter; measure structural response and dynamics from docking, control, and propulsive impulses; measure thermal and dimensional effects over long space exposures; verify math models/scaling laws.

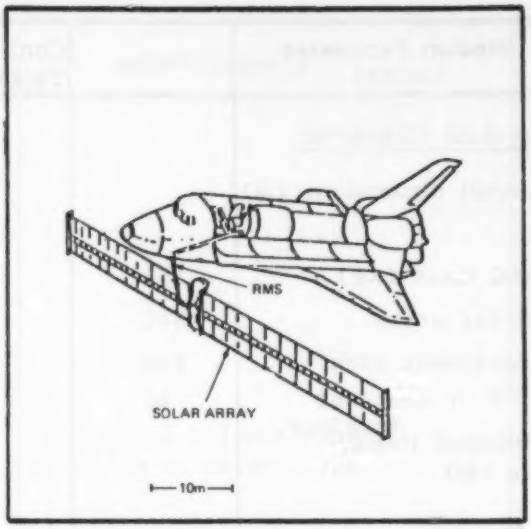
Program in Low Siffness Planar Structures: 100-m Free-Flying Truss
Measure modal responses and damping free from orbiter; measure structural response and dynamics from docking, control, and propulsive impulses; measure thermal and dimensional effects over long space exposures; verifiy math models/scaling laws.

Program in Precision/Shaped Structures: Free-Flying Antenna
Verify free structral dynamics with on-board shakers; measure thermal/dimensional effects over extended periods; determine response to docking impulses; verify anaytical models.

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Power Extension Package (PEP) U-6

Status:	Planned
Lifetime:	48-day mission (maximum)
Launch and Transfer Vehicles:	Shuttle
Operational Location:	LEO
Total Mass at Operational Location:	950 kg
Average Operational Power:	26 kW



OBJECTIVE:

Provide additional on-orbit power which will enable longer flights and higher power payloads to be flown.

DESCRIPTION: The Power Extension Package (PEP) is a supplemental power source that is used to supply power to the Shuttle Oribter to enhance mission capability. The PEP will augment the fuel cells such that cryogenic consumption can be reduced, therefore providing the capability of extending Shuttle missions. The Remote Manipulator System (RMS) deploys the PEP from the payload bay and then the power supply module consisting of folded solar panels and 2 canister assemblies which contain the solar array extension mast. Upon deployment of the power supply module, the solar array extension mast will be extended which in turn will pull the solar array panels from their folded position to form 2 separate solar array panels. When activated, the solar panels will supply up to 26 kW of power to the Orbiter. When in orbit around the dark side of the earth and when the PEP cannot supply the required power to the Orbiter, the fuel cells will automatically supply the required power.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Solar array and supporting equipment, power conditioning equipment.

REFERENCES:

J.I. Alarid, W.W. Blazer, Interface Definition Document, Power Extension Package, Rockwell International Space Division, June 1979; G.F. Haley, System Specification--Power Extension Package-Orbiter, McDonnell Douglas Astronautics Co., 11 July 1979.

CONTACTS:

W. Smith, NASA HQ, Code MTG-3, 755-3024

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Power Extension Package (PEP) U-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total mass (kg)	950	2	
Solar array	540	2	
Equipment rack	260	2	
PEP or Hachment fittings	40	2	
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	up to 48	2	
Number of spacecraft			
Life (yrs)	10	2, EV	At least 8 missions (14 days each) per year. At least 240 array extensions and retentions shall be possible.
Orbit			
Altitude (km)	185-110	1	Normal STS range
Inclination (deg)	28.5-104	1	

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Power Extension Package (PEP) U-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			Control positioning and pointing of solar array.
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			Normal to sun
Position accuracy (km)			
Pointing accuracy (mrad)	±35	2	Updated every 56 min.
Stability (mrad)			
Type of control system			Sun sensors and 2-axis gimbals

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Power Extension Package (PEP) U-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	0.2	2	From orbiter fuel cells
Peak power consumed (kWe)	26 for 56 min.	2	Power produced: 11 kW for orbiter operations, 15 kW for payloads
Power breakdown (We)			
Solar and degradation	10%	2, EV	After 80 14 day missions
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

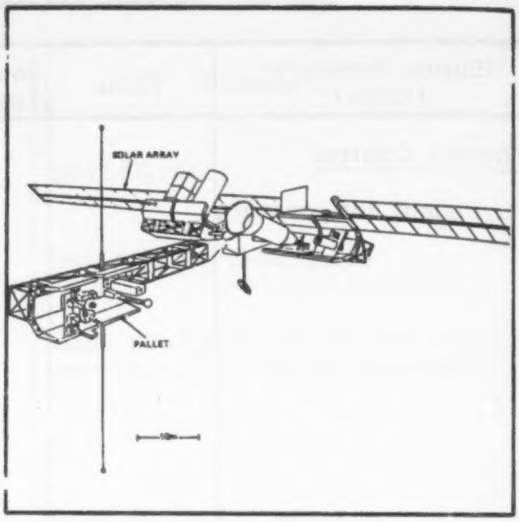
MISSION: Power Extension Package (PEP) U-6

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1.			
2.			
3.			
Component load (Wt)			
1. Radiator and flash evaporator	3 k (max)	2	
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Science and Applications Space Platform (SASP) U-7

Status:	Planned
Lifetime:	10 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	
Total Mass at Operational Location:	40,000 kg
Average Operational Power:	25 kW



OBJECTIVE: A permanent operational base and laboratory to support or enable several missions perceived to be of value: solar power system development, zero-g manufacturing, earth observation/communication/navigation, life sciences, and celestial/solar observation.

DESCRIPTION: A modular approach to space platform configurations is taken. These include a power module, platform support modules (one is pressurizable for life sciences operations), deployable structural elements, antennae, rotary joints, and payload carriers. These building blocks can be assembled in various configurations depending upon the mission requirements. The deployable structural elements are themselves modular and can be added to or deleted from the platform to make the arms shorter or longer. Each platform can therefore be configured on the ground or on orbit depending upon the individual payload element or discipline viewing requirements. The arms of these platforms can be either fixed or rotatable, depending on the payload viewing requirements.

CRITICAL TECHNOLOGY NEEDS:

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Varied.

REFERENCES: M. E. Nein, J. M. Butler, Jr., Mission Requirements and Design Concepts for Space Platforms, MSFC, AIAA paper 70-0941; W. J. Cuneo, D. P. Williams, Space Platforms for NASA, Opportunity or Pitfall, from Proceedings of Sixteenth Space Congress, Cocoa Beach, Florida, 25-27 April 1979.

Science and Applications Study Report, MSFC, Program Development, 1 April, 1979.

Conceptual Design Study (SASP), McDonnell-Douglas MDCG8257, First Quarterly Briefing, December 1979.

CONTACTS:

T. Hagler, NASA HQ, Code MTG-3

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Science and Applications Space Platform U-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	83.5 x 13.1 x 9		LWH, power module
	9.6		L, strong back module
Total mass (kg)	25,000-40,000		3-12 in use, 6 typical per flight
Payload	150-14,000		Mass dependent upon orbital inclination option chosen
Power module	13,311		Varies with experiment
Propulsion	3000-5000		Annual requirement
Deployed items, size (m)			
1.			EVA for construction, deployment, special operations, refurbishment
2.			
Cryogenics			Liquid hydrogen, liquid helium, super critical helium, super fluid helium
Life			
Flight duration (days)	3650		
Number of spacecraft	TBD		
Service interval (mo)	1-12		For payload refurbishment, etc.
Orbit			
Altitude (km)	TBD		More than 80% payload satisfied with 400-500 km altitude and inclinations of 28°-57°
Inclination (deg)	28-90		

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Science and Applications Space Platform U-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)	1×10^{12}		6 payload platform
Storage capacity (bits)			
I/O rates (bps)	1×10^{2} - 1.4×10^{7}		
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			View: Solar, earth, magnetic field lines, anti-earth, celestial, none
Position accuracy (km)			
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Science and Applications Space Platform U-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			
Average power consumed (kWe)	25		25 kW power system
Peak power consumed (kWe)	59		
Power breakdown (We)			
Payloads	5000-20,000		Payload dependent
Energy Storage			
Storage type	NiCd batteries		
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TDRSS multiplexed digital 25% duty cycle, 50 Mbps, 12.5 Mbps effective		

UTILIZATION OF SPACE ENVIRONMENT

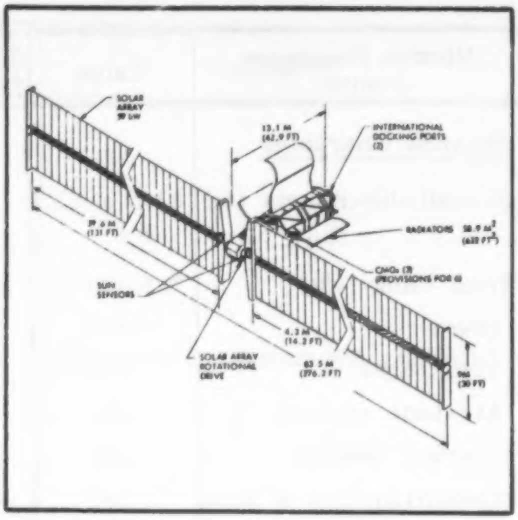
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Science and Applications Space Platform U-7

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Radiators	278-311		240-m^2 area
2.			
3.			
Component load (Wt)			
1. Radiators	10,000 - 25,000		
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)	283		
Propellant (kg)	3000-5000		Annual requirements for drag removal Electric propulsion might be a candidate except for the relatively high cost

MISSION: 25-kW Power System U-8

Status:	Planned
Lifetime:	10 years
Launch and Transfer Vehicles:	Shuttle
Operational Location:	LEO or GEO
Total Mass at Operational Location:	13,967 kg
Average Operational Power:	25 kW


SOLAR ARRAY 29 kW
13.1 M (42.9 FT)
INTERNATIONAL DOCKING PORTS (2)
39.6 M (131 FT)
RADIATORS 58.9 M^2 (632 FT^2)
CMGs (3) (PROVISIONS FOR 6)
SUN SENSORS
4.3 M (14.2 FT)
SOLAR ARRAY ROTATIONAL DRIVE
83.5 M (276.2 FT)
9M (30 FT)

OBJECTIVE: The 25-kW Power System provides electrical power, attitude control, and heat rejection for the STS Orbiter in the sortie mode. This functionally alleviates Orbiter/Spacelab limitations & enables support of long duration missions beyond present STS capabilities. Between sortie missions, the Power System provides a free-flying capability for science and applications payloads.

DESCRIPTION: The preliminary concept utilized existing Apollo Telescope Mount (ATM) structures for the equipment rack & primary structure. A new design tubular forward truss provides the structure for mounting a single-axis gimballed solar array. The tubular truss aft structure provides for 2 docking ports to permit simultaneous coupling with the Orbiter for sortie operations, & a payload for free-flyer operations. Umbilicals are provided at each port for transfer of electrical power, coolant. commands, & data. The Orbiter Remote Manipulator (RMS) is used for deployment & docking. A grappling fixture is provided for use by the RMS in removing the PM from the payload bay, & performing docking & berthing. Electrical power is obtained from a single-axis tracking array that is based on SEPS solar array technology developments. Sun sensors are used to search & point the array to the sun. Reference secondary batteries are derived from the SEASAT design. The battery charge control & power regulation functions are provided by programmable power processors (p^3) under development.

CRITICAL TECHNOLOGY NEEDS: None

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES: 25-kW Power Module Evaluation Study, LMSC for MSFC, Contract NAS8-32928, Part I-Payload Requirements & Growth Scenarios (Final Report), 8/1/78; Part II-Payload Supports & System Evolution (Final Report), 9/30/78; Part III-Conceptual Designs for Power Module Evolution, Vols. 1-6, (Final Report), 1/27/79; Executive Summary 2/27/79.

CONTACTS:

W. Kisko, NASA HQ, MTG-3
W. Smith, NASA HA, MTG-3

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: 25-kW Power System U-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	83.5 x 13.1 x 9		LWH
Total mass (kg)	13,967		
Power	6810		
Structures	3714		
Attitude control	1233		
Thermal control	1262		
Communications & Data	292		
Propulsion module	656		
Deployed items, size (m)			
1. Solar array	83.5		Total, two 39.6-m panels
2.			
Life			
Flight duration (days)	1825		
Number of spacecraft			
Service interval (yrs)	5		
Orbit			
Altitude (km)	435 to 35,786		
Inclination (deg)	28.5-57 polar 0		Will operate in one fixed TBD inclination

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: 25-kW Power System U-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)	4000		Telemetry, command and control
Spacecraft processors/ computers	NSSC-II		
I/O rates (bps)			
Memory size (bits)	256,432		16 K words, 16-bit words
Speed (ops/sec)			
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			Celestial/stellar inertial/ solar observation/earth limb observation/earth nadir observation
Position accuracy (km)			
Pointing accuracy (mrad)	8.7		
Stability (mrad)			
Type of control system	Sun sensors/control moment gyros (CMG)/star trackers/ horizon sensors		

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: 25-kW Power System U-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic
Average power consumed (kWe)	25		
Peak power consumed (kWe)	59		
Power breakdown (We)			
Energy Storage			
Storage type	NiCd batteries		12 -110 cell batteries 60 AH each
Energy/cycle (J)			22% DoD
Communications			
Link, type of data and rate (Mbps)	TDRSS/ Shuttle 4 kbps		

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

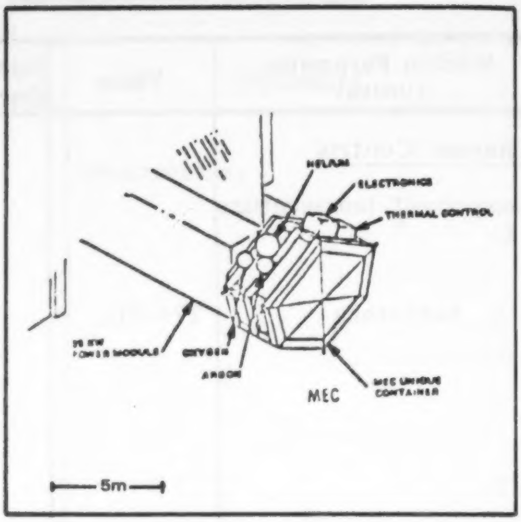
MISSION: 25-kW Power System U-8

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Radiators	279-311		58.9 m^2 area
2.			
3.			
Component load (Wt)			
1. Radiators	5000-14,000		
2.			
3.			
Propulsion			
Total ΔV required (m/sec)	TBD		Drag make-up requirement TBD
			Propulsion unit sizing (in-house estimates)
Thrust level (N)	TBD		
			Dry mass 144 kg
I_{sp} of stages (sec)	TBD		Propulsion 512 kg
			Hydrazine propellant
Special			
man involvement	EVA necessary for inspection, refurbishment		

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Material Experiment Carrier (MEC) U-9

Status:	Planned
Lifetime:	5 years
Launch and Transfer Vehicles:	Shuttle/Power System
Operational Location:	LEO
Total Mass at Operational Location:	5000 kg
Average Operational Power:	15 kW



OBJECTIVE: The Materials Experiment Carrier (MEC) is intended to provide the capability to process large numbers of materials research experiments in a near weightless environment while attached to the power system in the free flyer mode. The MEC will provide the mechanical, electrical, thermal, and command and data management interface between the power system and the materials research apparatus.

DESCRIPTION: The MEC will service up to six materials research experiments during any mission and will be designed to facilitate variations in the mix of apparatus on any given mission. The MEC will be transported to LEO by the Shuttle and attached to the power system for extended operation thus freeing the Shuttle for other tasks.

CRITICAL TECHNOLOGY NEEDS: High-temperature thermal systems; space adapted material handling and storage system; automated sample analysis process surveillance and control equipment.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

REFERENCES:

TRW Report, Experiment and Payload Requirements for the Materials Experiment and Carrier, Contract NAS8-33278, May 1976.

CONTACTS:

J. Carruthers, NASA HQ, EM-7
Mark Nolan, NASA HQ, MTC-3

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Material Experiment Carrier (MEC) U-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)	6 x 4.6		L x D
Total mass (kg)	5000		
Deployed items, size (m)			
1.			
2.			
Life			
Flight duration (days)	30-90		5-yr hardware life possible refurbishment
Number of spacecraft	1		
Orbit			
Altitude (km)			
Inclination (deg)	~28		Not critical

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Material Experiment Carrier (MEC) U-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers			
I/O rates (bps)			
Memory size (bits)			
Speed (ops/sec)			
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			10^{-5} g's maximum experienced by an experiment over an extended period of time Lesser values desired
Pointing accuracy (mrad)			
Stability (mrad)			
Type of control system			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Material Experiment Carrier (MEC) U-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Uses 25 kW power system
Average power consumed (kWe)	15	(3, SOA)	
Peak power consumed (kWe)			
Power breakdown (We)			
Energy Storage			
Storage type			
Energy/cycle (J)			
Communications			
Link, type of data and rate (Mbps)	TDRSS		

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Material Experiment Carrier (MEC) U-9

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			High temperature components, pumps, working fluids, highly durable thermal control coatings
Component temperature (K)			
1. Heat pipe radiators	373/311		In/out
2.			
3.			
Component load (Wt)			
1.			
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION: Materials Experimentation Carrier II U-10

Status: Planned

Lifetime:

Launch and Transfer Vehicles:

Operational Location:

Total Mass at Operational Location:

Average Operational Power:

OBJECTIVE: To provide a follow-on capability for materials processing after the five years of MEC research.

DESCRIPTION: MEC II is envisioned as larger than MEC, probably emphasizing standardized components. MEC II will probably feature considerable use by commercial space processors. The options for MEC II today range from one large facility to many separate smaller facilities.

CRITICAL TECHNOLOGY NEEDS:

Low cost power [<$40/kWh ($78) is a good target]

INSTRUMENT OR EXPERIMENT COMPLEMENT:

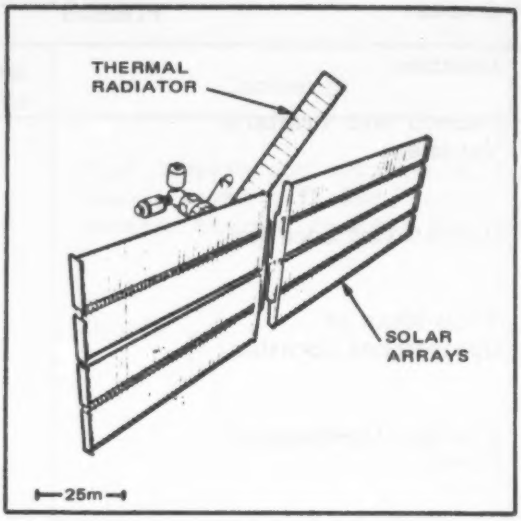
REFERENCES:

CONTACTS:

M. Nolan, NASA HQ, MTC-3
J. Carruthers, EM-7

MISSION: Large Power Module U-11

Status:	Planned
Lifetime:	15-20 years with refurbishments
Launch and Transfer Vehicles:	Shuttle and OTV for GEO
Operational Location:	Low earth orbit with 28.5°, 57°, and polar inclination, and geo-synchronous orbit
Total Mass at Operational Location:	29,300 kg
Average Operational Power:	200-300 kW



OBJECTIVE:
Provide a modularized expandable power module which will be needed for large free-flying payloads, such as space manufacturing, space platforms, space construction bases, and geosynchronous communications/earth observations systems.

DESCRIPTION:
The Large Power Module will be the final evolutionary growth of the 25-kW Power Module and its expansions, utilizing the latest available technology. It will employ the same basic modular concepts, expanded to much larger power levels, and could be either a completely new system or could consist of an on-orbit up-grading and refurbishment of a smaller power module. Several such modules are envisioned at various altitudes and inclinations to satisfy different user requirements.

CRITICAL TECHNOLOGY NEEDS: Advanced batteries, lightweight structures, efficient solar arrays, long-life lightweight radiators, advanced gyros and momentum control equipment, drag compensation system.

INSTRUMENT OR EXPERIMENT COMPLEMENT:

Attitude control, thermal control, communications and data handling, electrical power, and structural subsystems.

REFERENCES:
25-kW Power Module Evolution Study, Volumes 1-3, Lockheed Missiles and Space Company, September 1978 - February 1979, NASA Accession No. N79-17887 to N79-17894, N79-20219.

CONTACTS:
W. Kisko, NASA HQ, Code MTG-3, 755-3024

UTILIZATION OF SPACE ENVIRONMENT
MISSION TECHNOLOGY REQUIREMENTS

MISSION: Large Power Module U-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Physical Character			
Overall dimensions (m)			
Total mass (kg)	29,230	3	For 200 kW version
Structure	5140		
Power	13,640		
Thermal control	2170		
Attitude control	2205		
Communications & data	230		
Contingency	5845		
Deployed items, size (m)			
1. Solar arrays	56 x 113	3, EV	Point normal to sun
2. Thermal radiator	150 x 4	3, EV	
Life			
Flight duration (days)			
Number of spacecraft			Several may be required, with various power levels.
Life (yrs)	15-20	2, EV	
Orbit			
Altitude (km)			Several large power modules may be required, some at LEO in various inclinations, such as 28.5°, 57°, and polar, and also at geosynchronous orbit.
Inclination (deg)			

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Large Power Module U-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Data			
Data volume (bits/day)			
Storage capacity (bits)			
I/O rates (bps)			
Spacecraft processors/ computers	NSSC-II	3, EV	Housekeeping functions
I/O rates (bps)			
Memory size (bits)	8.2×10^6	3, SOA	
Speed (ops/sec)	122,000	3, SOA	
Ground Processors/ computers			
Memory size (bits)			
Guidance & Attitude Control			
Position accuracy (km)			
Pointing accuracy (mrad)	±10	2, SOA	For solar arrays
Stability (mrad)	0.15	2, EV	
Type of control system			Horizon sensor, sun sensors, star trackers, rategyros, CMG's, magentometer.

UTILIZATION OF SPACE ENVIRONMENT

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Large Power Module U-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Power			Photovoltaic (GaAs)
Average power consumed (kWe)	200-500		
Peak power consumed (kWe)			
Power breakdown (We)			
High voltage (V)	220	3, EV	
Energy Storage			
Storage type	NiH_2 batteries or regenerative fuel cells		
Energy/cycle (J)			80% depth of discharge for batteries
Communications			
Link, type of data and rate (Mbps)	Telemetry, digital, 256 kbps Data from attached sensors Digital, up to 300 Mbps		relayed through TDRSS

MISSION TECHNOLOGY REQUIREMENTS

MISSION: Large Power Module U-11

Mission Parameter (units)	Value	Confidence Level, Technology State	Comments
Thermal Control			
Component temperature (K)			
1. Battery	283		
2.			
3.			
Component load (Wt)			
1. Radiator	41,000	3, EV	135 m^2 area for 200 kW system
2.			
3.			
Propulsion			
Total ΔV required (m/sec)			
Thrust level (N)			
I_{sp} of stages (sec)			

Utilization of Space Environment Instruments

UI-1	Instrument Pointing System
UI-2	AGS Pointing System
UI-3	Fluid Experiment System
UI-4	Gradiometer
UI-5	Solidification Experiment System
UI-6	High Gradient Furnace System
UI-7	Acoustic Containerless Processing Module
UI-8	Electromagnetic Containerless Processing System
UI-9	Isoelectric Focusing System
UI-10	Biological Processing System
UI-11	Analytical Floating Zone System
UI-12	Space Vacuum Research Demonstration

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INSTRUMENT: Instrument Pointing System (IPS) UI-1

STATUS: Approved

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The IPS provides precision pointing for payloads that require greater pointing accuracy and stability than is provided by orbiter. Its gimbal system is attached to the payload when in orbit, and performs the control maneuvers required by the observation program. The IPS provides three-axis attitude control and stabilization for experiments. Attitude control of the payload is based on rate-integrating gyro error signals processed within the Spacelab computer to generate command signals.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Pointing accuracy (arc sec)
  Line of sight: 0.8-2
  Roll: 15-40
Quiescent stability error (arc sec)
  Line of sight: 0.33-1
  Roll: 1.6-3
Pointing range
  Line of sight (rad): 3.14
  Roll (rad): ±3.14

Stability rate
  Line of sight (arc min/sec): 1, peak
  Roll (arc sec/sec): 130, peak
  Line of sight (arc sec/sec): 5, rms
  Roll (arc sec/sec): 25, rms
Slewing rate (deg/sec): 2.5, max

ASSOCIATED RANGES AND/OR RESOLUTION:

Nominal payload capabilities:

	Large	Small
Mass (kg)	2000	200
Dimensions (m)	26 × 4	1 × 1.5

COMMENTS:

To correct for gyro drift and to provide absolute attitude reference, a package of optical sensors is also included. In a stellar mission, this would consist of 3 star trackers; in a solar mission, one star tracker would be replaced by a solar sensor.

SOURCE/CONTACT:

R. Kennedy, NASA HQ, Code SM-8

INSTRUMENT: AGS Pointing System UI-2

STATUS: Approved

CARRIER: Spacelab 5

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.1 × 1 dia; 2-Gimbal
1.4 × 1 dia; 3-Gimbal

Mass (kg): 250; 2-Gimbal
291; 3-Gimbal

Power Requirement (We):

	Standby	Peak	
	341	1325	2-Gimbal
	355	1540	3-Gimbal

Data Rate (kbps): Payload unique

PRINCIPAL PURPOSE AND FEATURES:

The AGS pointing system is a general-purpose mount designed to provide orientation, mechanical isolation and pointing for space experiment. Concepts are for a two or three gimbal approach.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Angular range: ±60° lateral
±100° elevation
±180° roll
Angular rate: ±1.6°/sec
Angular acceleration: ±2000 $\widehat{\text{sec}}/\text{sec}^2$
Command response: 0.05 $\widehat{\text{sec}}$ resolution
Pointing accuracy: 0.01 $\widehat{\text{sec}}$ payload
2 $\widehat{\text{sec}}$ stellar reference

LOS quiescent stability: 0.2 $\widehat{\text{sec}}$
LOS peak disburbance: 0.4-0.9 $\widehat{\text{sec}}$, 60-600 kg payload
* Roll quiescent stability: 2.5 $\widehat{\text{sec}}$
* Roll peak disturbance: 5 $\widehat{\text{sec}}$, 60-600 kg payload

*3-Gimbal system only

ASSOCIATED RANGES AND/OR RESOLUTION:

Payload accommodation
Size: 1.0 m dia, may overhang, any length
Mass (kg): 60-7200
CM offset (m): 0.15-5.0
LOS inertia (kg-m^2): 4-50,000
Roll inertia (kg-m^2): 2-50,000

COMMENTS:

Also known as Annular Pointing and Suspension System Gimbal System Pointing System, a derivative of the Annular Momentum Control Device. Candidate Systems for AGS are Solar Optical Telescope, SIRTF, UV Telescope, UV Solar Telescope, UV Space Polarimeter.

SOURCE/CONTACT:

R. Kennedy, NASA HQ, SM-8

INSTRUMENT: Fluid Experiment System UI-3

STATUS: Approved **CARRIER**: Spacelab-3

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 2 kW

Mass (kg):

Data Rage (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The purpose of the FES is to conduct experiments in space related to (1) assessing how reduced conductive flow will affect the processing of various materials in space, and (2) learning what the effects of gravitational forces are on processes which are performed on earth. Experiment system equipment consists of two principle subsystems: support module and the experiment module.

PRINCIPAL PHYSICAL PROPERTIES MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Typical Experiments:

1. Crystal Growth and Solidification
   - Growth kinetics measurements
   - Solution growth of inorganic crystals
   - Protein and macromolecular crystal growth
2. Containerless Processing
   - Electrostatic positioning demonstration and test
   - Surface shape stability tests for unusual floating zone configurations
3. Fluid and Chemical Processing
   - Convection phenomena at low-g
     - Thermosolutal effects
     - Electrohydrodynamic phenomena
     - Non-Boussinesq behavior
   - Thermocapillary convection studies
     - Bubble Dynamics
     - Drop dynamics
     - Thermophoresis

3. Fluid and Chemical Processing (Cont.)
   - Phase transformation
     - Phase separation-spinodal/nucleated
     - Critical point phenomena
   - Chemical precipitation
     - Ostwald ripening
     - Flocculation
   - Transport phenomena
     - Soret diffusion
     - Electromigration
   - Multiphase systems
     - Droplet arrays
     - Bubble arrays and foam behavior
     - Solid-liquid-gas interactions during phase transformations
   - Rheological behavior of liquids
     - Blood

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INSTRUMENT: Fluid Experiment System (Cont.) UI-3

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION (Cont.):

The support module includes those functions common to all FES experiments:

- The optical subassembly to provide holograhic recording of the experiment process and real-time Schlieren views of the experiment zone.
- Thermal control of the experiment module and the optics.
- Command and data control for the system.
- Electrical power for the optical assembly, experiment module, thermal cooling, and other functions.
- An experiment enclosure to secure the experiment module.
- Storage for experiment modules not in use.
- Common diagnostics (currently accelerometers, temperature probes, and the verification-calibration-characterization cell).

ASSOCIATED RANGES AND/OR RESOLUTION:

FES Experiment Module (EM)

1. The FES EM contains the experiment-unique part of any FES experiment.
2. The experiment fluid or fluids are contained in the EM. At present, there is no ancillary fluid vessel on FES.
3. The size of the EM viewed volume can be up to one liter.
4. The EM cell walls can be tailored to maintain an isothermal environment or a thermal gradient, wall temperatures controlled to ±0.01°C.
5. The EM is provided with an insert for reaction initiation or specimen insertion.
6. The viewing ports are: a 10 cm × 10 cm window pair to view directly through the experiment; a side port 3.5 cm × 3.5 cm for scattered light holograms.
7. Temperature control functions, temperature sensing functions, electrical functions are contained in the cell and interfaced to the data and control subsystem in the support module.

FES Optical System

1. Laser - HE/NE: 30 MW; 632.8 nm
2. Illuminated area: collimated beam 10 cm × 10 cm area; scattered light 5-cm diameter window
3. Exposure time: 0.1-10 sec
4. Frame rate: 2 per minute limited by film transport
5. Frames per magazine: 150-200; 1 magazine per experiment at each port
6. Spatial resolution: ≤20 μm changes in crystal boundary in 2 cm by 2 cm FOV
7. Schlieren resolution: visualization of flow from 0.2% concentration change over 0.05 mm
8. Schlieren data format: vidicon (real-time)

COMMENTS: Low drag requirements: 10^{-7}-10^{-5} g's.

SOURCE/CONTACT: Announcement of Opportunity: Fluids Investigations in Space Related to Materials Processing, AO:OSTA:80-1, 10 March 1980.

J. Carruthers, EM-7.

INSTRUMENT: Gradiometer

UI-4

STATUS: Planned

CARRIER: Tethered Satellite System

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To permit in situ studies (down to altitudes of about 120 to 100 km) of gravitational fields and prototype space crane.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Earth's gravity field
Sensitivity: 0.25-1 EU

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

E.J. Brazill, NASA HQ, MTG-3, 755-3024
M. Page, MSFC

INSTRUMENT: Solidification Experiment System UI-5

STATUS: Planned **CARRIER**: Spacelab Pallet

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To process large numbers of materials research experiments in a near weightless environment. System consists of a support module and a furnace module.

Typical Experiments: Ionic and Electron Transport in Solid-State Electrolytes; Magnetic Properties of Eutectic and Peritectic Directional Solidified Alloys; Compound and Alloy Semiconductor Crystal Growth; Chemical Vapor Transport Crystal Growth; Determines Structure Versus Properties and the Processes Occurring During Solidification of Immiscible Metals; Alloy Semiconductor Growth for IR Detectors; Preparation of Composite Metal Structures.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: The base line furnace module provides the following: up to 24 different samples; sample size range 1.27 cm OD × 2.54 cm to 3.175 cm OD × 25.4 cm; room temperature to 1600°C; programmed cooling rate ≤500°C/hr; power requirements ≤3 kW; radial temperature gradient < ±0.05% above 500°C, 0.2°C/cm below 500°C; temperature gradient between 50°C/cm to 400°C/cm over distance of 5 mm or less; temperature uniformity ±0.05% of operating temperature over 25.4 cm length; radial temperature uniformity ±0.05% of operating temperature; interface maximum translation rates 0.1 mm/hr to 500 mm/hr; capability to quench cavity with He - quench rate ≥300°C/min.

ASSOCIATED RANGES AND/OR RESOLUTION:

Support module subsystems	Furnace module subsystems
common chamber	sample heating
thermal control	sample insertion/retrieval
command and data	
gas/vacuum	
electrical	

COMMENTS:

12 flights with refurbishment

SOURCE/CONTACT:

Materials Processing in Space Program, Handbook for Participants, ORITR-1665
February 1980
J. Carruthers, NASA HQ, EM-7

INSTRUMENT: High Gradient Furnace System UI-6

STATUS: Planned

CARRIER: Materials Experiment Carrier (MEC)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

The High Gradient Furnace System will be an apparatus for controlled directional solidification of semiconductor alloys and analogous materials that require maintenance of temperature gradients as much as 1000° C/cm in the melt in order to establish solidification conditions at the solid/liquid interface. It will be used to investigate solidification processes under these extreme conditions and to develop methods for preparing homogenous single crystals of semiconductor alloys for large area infrared imaging arrays and other applications.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Essential technology should be developed by 1981. Design life is 10 flights with refurbishment.

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7

INSTRUMENT: Acoustic Containerless Processing Module (ACPM) UI-7

STATUS: Planned

CARRIER: Materials Experiment Carrier (MEC)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.07 × 0.99 × 1.03

Power Requirement (We): 550

Mass (kg):

Data Rate (kbps): 1.2

PRINCIPAL PURPOSE AND FEATURES: The system will levitate, position, and manipulate experiment samples in a tri-axial acoustic field while the sample is melted and solidified in a weightless environment. The gas atmosphere used to transmit the acoustic forces can be inert or reacting as required. Investigations using this capability will include the formation of new glasses from reactive materials or materials that are reluctant glass formers when prepared in a crucible, glass fining and nucleation studies, studies into the dimensional control during the formation of glass inertial confinement fusion targets, and studies on purity control in glass materials (e.g. optical fibers).

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION

See attachment.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Operating times in excess of 100 hr should be anticipated. Accelerations must be maintained below 10^{-6} g's and angular motions below 0.10°/sec during the operation of the ACPM. Anticipated design life is 5 flights with refurbishments.

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7
Acoustic Containerless Processing Module Final Report, JPL 730-35, 15 March 1979

INSTRUMENT: Acoustic Containerless Processing Module (ACPM) (Cont.) UI-7

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

1. Sample can be: deployed, heated, formed, spun, mixed, oscillated, cooled, retrieved
2. Sample size range 0.5 to 2.5 cm
3. Sample rotation of 12 rad/sec
4. Deployment of sample at chamber center
5. Storage for 25 samples
6. Imaging of chamber interior from two orthogonal directions
7. Indirect video viewing
8. Record an image from two directions
9. Image recording to 64 fr/sec
10. Define sample size and shape to 0.02 cm
11. 48,000 image capacity
12. Grid or reseau pattern for image location to ±0.02 cm
13. Illumination by supplementary lighting
14. Field of view 6.6 cm diameter at chamber center plane
15. Magnification of image
16. Video linked to shuttle TV
17. Video to real-time downlink
18. Color photography optional
19. Illumination intensity sufficient to see clear glass sample against background
20. Sample isothermal ±10°C at maximum temperature
21. Infrared radiance profile of sample photos
22. Spot heating with CO_2 laser for demonstration
23. Acoustic force field, spherical to ±2 dynes within 1 cm radius with center at pressure null
24. Acoustic pressure rise time of <0.1 sec
25. Acoustic centering forces: 2.5 cm sample sp. gr. of 9, within 3 cm of center, with constant acceleration of up to 10^{-3} G
26. Sound pressure field modulation index of ≥20% at 30 Hz
27. Oscillation force in any or all three chamber axes
28. Oscillation stimulus freqencies of 0.1 to 30 Hz
29. Sample cooling rate approximately 4°C/sec with O_2, N_2, CO_2, and 8°C with He
30. Temperature control of sample by incident radiation
31. Bubble inclusion in prepared sample
32. Servo will monitor sample drift and prevent wall contact
33. Experiment duration of 1-2 hr
34. Chamber heating and evacuation for cleaning
35. Chamber temperature less than 1450°C
36. Sample rotation about 1 axis
37. Rotational capability of sample about two orthogonal sample axes
38. Z axis modulation phase fixed
39. Possible to stimulate modes 2 and 4
40. Maximum oscillation force for 2.5 cm sample is 10 dynes
41. Oscillation signal available in 0° and 180° phase
42. Gases are O_2, N_2, CO_2, Ar, or He
43. Gas purity of 99.9%
44. Automatic control of function with limited manual override

INSTRUMENT: Electromagnetic Containerless Processing System (ECPS) UI-8

STATUS: Planned

CARRIER: Materials Experiment Carrier (MEC)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: This system will apply electromagnetic induction for position control, and in some cases, heating of conducting materials in a vacuum or in an inert or reacting atmosphere. Investigations using its capabilities will include preparation of amorphous ferromagnetic materials with no hysteresis, investigation of the fundamental properties of metallic glass materials, tests of the theory of undercooling and crystal nucleation, measurement of the high temperature and thermodynamic properties of very pure materials, and evaporative purification of refractory metals.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

See attached page.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Accelerations must be maintained at or below 10^{-6} g's during experiment runs, and angular motions must be maintained at or below 0.10°/sec. Running time in excess of 100 hr should be expected. Design life is 5 flights with refurbishment.

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7
Electromagnetic Containerless Processing Task Team Meeting, 16-17 October 1979, MSFC, 21 January 1980.

INSTRUMENT: Electromagnetic Containerless Processing System (ECPS) (Cont.) UI-8

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Experiment	Environment	Temperature Range	Specimen Size, Number	Materials	Observation Requirements
Enthaply of materials at high temperature	10^{-5} torr	1000 to >3600°C	0.2-1 cm several sizes per material	Metals Oxides Carbides	Temperature ±0.5%; radiation energy ±2%; imagery 0.01 cm 16 sec^{-1}
Effects of flow upon nucleation and grain refinement in solidifying metals	10^{-5} to 10^{+2} torr	30-2000°C	0.5-10 cm, 3 per material	Metals	Temperature ±1%; imagery 0.01 cm 100 sec^{-1}
Properties of materials at high temperatures for reactor safety studies	10^{-5} torr to high pressure	1500 to >5000°C	0.5-10 cm, 6 per material	Metals Oxides Stone Mixtures Concrete	Temperature ±1%; evaporation rate ±10%; reflection light ±10%; imagery 0.01 cm 16 sec^{-1}; calory temperature ±0.01 Cdeg
Properties of materials at high temperatures	10^{-5} torr to several atmospheres	1500 to >5000°C	0.0-1 cm, 24 per flight	Metals Oxides Carbides	Temperature ±0.2% repro.; evaporation rate ±10%; imagery 0.01 cm 16 sec^{-1}; calory temperature ±0.01 Cdeg
Phase transitions in solids and nucleation in undercooled melts	10^{-9} to 10^{+2} torr	0 to 2000°C	0.01-1 cm, 1000/swarm, dozens per material	Metals and surface coatings	Temperature ±1%; imagery <0.01 cm 16 sec^{-1}
Formation of amorphous solids	10^{-9} torr to one atmosphere	<100 to 2000°C	0.01-1 cm, 6 per material	Metals	Temperature ±1%; imagery 0.001 cm 16 sec^{-1}

INSTRUMENT: Isoelectric Focusing System UI-9

STATUS: Planned **CARRIER:** Shuttle/Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We):

Mass (kg):

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

Equipment will be developed to implement advanced, space-based concepts for separation and purification of biological materials by isoelectric focusing, an electrokinetic separation method that distinguishes molecules or particles by their differing affinities for hydrogen ions in electrolytes. Included among the concepts to be tested will be large scale synthetic protein separation, cell separations depending on alteration of surface properties by attachment of polymer microspheres, and trials of analogous techniques that can be performed in the same apparatus.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Design life is 5 flights with refurbishment.

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7

INSTRUMENT: Biological Processing System (BPS) UI-10

STATUS: Planned **CARRIER**: STS

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): TBD **Power Requirement (We)**: TBD

Mass (kg): TBD **Data Rate (kbps)**: TBD

PRINCIPAL PURPOSE AND FEATURES: Current investigations in biological applications of materials processing in space include work on separation and purification by electrophoresis, isoelectric focusing and counter current distribution, research on separation enhancement for cells by modifying their surfaces through attachment of microspheres,and development of space-based cell culturing methods for sample preservation and possibly for production of biological materials. As these investigations mature, they are expected to develop requirements for space experimentation using more capable apparatus than that available from pre-STS programs.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

Full automation may be feasible in the next generation of bioprocessing payloads following the BPS. At this time, basic technology appears to be adequate to implement the experiments that can be foreseen. Design life is 5 missions with refurbishments.

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7

INSTRUMENT: Analytical Floating Zone System UI-11

STATUS: Planned **CARRIER**: Shuttle/Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.6-0.9 m^3

Power Requirement (We): 1250

Mass (kg): 320-420 kg

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To study the process parameters of molten zone crystal growth under weightless conditions. Experiments will be performed at temperatures up to 1200°C to study Marangoni convection, liquid shape stability, spacecraft acceleration effects, thermal gradient control, constitutional stability at the liquid/solid interface, etc. Experiment runs will be on the order of 10 hrs. long with acceleration rates at or below 10^{-5}g and vehicle rotation rate no more than 0.1°/sec.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: Typical experiments:

1. Determine if surface tension-driven convection can be eliminated by oxide layers in float zone experiments
2. Measure mass diffusion coefficients in reactive metals
3. Grow crystals of incongruently melting materials
4. Study Marangoni convection
5. Study convection in float zones of transparent liquid solutions

ASSOCIATED RANGES AND/OR RESOLUTION:

Rotation: 0-100 rpm; axial travel: 10-15 cm; axial motion rate: 6 × 10^{-3}-6 mm/min; axial stability: ±1%; compression travel: 0-5 cm; compression rate: 6mm/min; compression stability: ±1%, convection velocities: 0-10 cm/sec; velocity sensor resolution: 110 μm; velocity accuracy: 1.5%; temperature range: 0-1500°C; temperature accuracy: ±2°C; temperature relative accuracy: ±0.1°C

COMMENTS:

Experiment complement: Gas analyzer or mass spectrometer, pressure measurement system, radiation pyrometer, laser Doppler velocimeter, TV, Cine camera, vacuum pump

SOURCE/CONTACT:

John Carruthers, NASA HQ, EM-7
Analytical Float Zone Experiments System (AFZES). Presentation by A.D. Little, Inc., 22June 1979

INSTRUMENT: Space Vacuum Research Demonstration UI-12

STATUS: Planned **CARRIER:** Space Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): **Power Requirement (We):**

Mass (kg): **Data Rate (kbps):**

PRINCIPAL PURPOSE AND FEATURES: The Space Vacuum Demonstration project will be undertaken to determine the performance to be expected of a fully developed orbital molecular shield vacuum facility and to characterize relevant features of the composition and molecular velocity distribution in the upper atmosphere. Positive results from these measurements would show that the molecular shield principle can be used to develop ultrahigh vacuums equivalent to the best levels ever obtained on earth, in volumes of the order of cubic meters, at very high effective pumping speeds, and with the ability to dissipate very large heat loads.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

A molecular wake shield of approximately 1 m diameter will be operated from the space shuttle, possibly using the shuttle itself to deflect atmospheric molecules away from the shield. Diagnostic instrumentation in the wake of the device will determine the composition of the gas in the wake, its velocity distribution, and the distribution of gas density as a function of position behind the shield. Design life is 5 missions with refurbishment with a launch date of 1987.

SOURCE/CONTACT:

FY 84 OSTA Plan, 6 March 1980
John Carruthers, NASA HQ, EM-7

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OAST Instruments

OI-1	Feature Identification and Landmark Experiment
OI-2	Induced Environment Contamination Monitor
OI-3	Drop Dynamics Module
OI-4	Solar Cell Calibration Facility
OI-5	Tribology
OI-6	Miniature Electrostatic Accelerometer (MESA)
OI-7	Super Fluid Helium Experiment
OI-8	Thermal Canister
OI-9	Infrared Materials
OI-10	Long Duration Exposure Facility
OI-11	8-cm Ion Engine Demonstration
OI-12	SEP Solar Array Shuttle Flight
OI-13	ASPS Vernier System
OI-14	Propulsion Contamination Effects

INSTRUMENT: Feature Identification and Landmark Experiment File-I) OI-1

STATUS: Approved **CARRIER:** Shuttle (OSTA-1)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.90 × 0.51 × 1.30 **Power Requirement (We):** 24 (70 max)

Mass (kg): 34 **Data Rate (kbps):** NA (no downlink)

PRINCIPAL PURPOSE AND FEATURES: To build, laboratory evaluate, and flight test aboard an early shuttle flight a landmark classification experiment. This system will be designed to improve data management in earth-observation missions, reduce mission-support costs, and provide inputs for development of a landmark identification and tracking system. This instrument should be capable of spectrally sensing and quantitatively classifying the earth's surface into vegetation, bare earth, water, and cloud cover. The following sensors will be needed for FILE: (1) a CCD camera with filter at 0.65 μm; (2) a CCD camera with filter at 0.85 μm; (3) a Hasselblad 70 mm film camera with color IR film; and (4) a sun sensor for experiment activation.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

CCD cameras: 17° × 23° FOV with a dynamic range greater than 40 to 1, spectral response in the range of 0.4 to 1.1 m, and a resolution of 1100 m/TV line. Hasselblad 70 mm film camera: FOV of 29.2° square with a resolution of 100 m/line pair.

COMMENTS:

SOURCE/CONTACT:

Proposal Fact Sheet/Gordon Bullock, LaRC, (804) 827-3551
Feature Identification and Location Experiment (FILE) Critical Design Review, Martin Marietta Aerospace and LaRC, 20 July 1978
J. Lundholm, NASA HQ, Code RSI

INSTRUMENT: Induced Environment Contamination Monitor (IECM) OI-2

STATUS: Approved **CARRIER**: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1.25 × 0.85 × 0.76 **Power Requirement (We)**: ND

Mass (kg): ≈338 **Data Rate (kbps)**: ND

PRINCIPAL PURPOSE AND FEATURES: To measure gaseous and particulate contaminants in a shuttle environment during ground handling, launch preparation, ascent, orbital operation, descent, landing, and payload removal. This will be accomplished with sufficient diagnostic detail to identify the sources responsible for any out-of-specification conditions. To be specific, the IECM will monitor the following.

1. Temperature and Humidity. To include air temperature, relative humidity, and dew point.
2. Trace Gases. Trace quantities of hydrocarbons, phthalate esters, and silicones in the payload bay atmosphere will be identified and analyzed to define the nature of the molecular film on surfaces when they are first exposed to the space environment.
3. Aerosol Count and Size Distribution. The particulate content of the payload bay atmosphere will be determined continuously in order to (a) assess quality of purge gas in the vicinity of the payload, (b) determine the effectiveness of work discipline control procedures by determining whether the class 100 k environment is maintained, and (c) to determine the types and sources of the particles collected.
4. Nonvolatile Residue Deposition. The amount of molecular film deposited on a surface in the payload bay environment will be measured as a function of time in order to (a) determine whether the allowed 1 $\mu g / cm^2$ is exceeded during pre-launch activities, (b) determine how much of this film remains in the space environment, and (c) determine how much additional film is collected from the induced environment.
5. Dust Fall Measurements. The amount of particulate material collecting on a surface will be measured in order to (a) determine how well the Level 300 A cleanliness can be maintained during launch, (b) determine how much dust is redistributed and/or deposited during launch, ascent and descent, and (c) determine the behavior of particules on surfaces in space.
6. Molecular Column Density (MCD). The integrated molecular column density along the spacecraft z-axis will be determined for various species in order to define the induced atmosphere through which light must travel and to calculate the IR background noise level.
7. Background Spectral Intensity. The background from sunlight scattered from molecules and small particles will be measured in the vicinity of the spacecraft. This will allow the determination of the number and projected area of the reflecting particles, from which upper limits of the scattered light from the IR through the UV may be estimated.

INSTRUMENT: Induced Environment Contamination Monitor (IECM) (Cont.) OI-2

PRINCIPAL PURPOSE AND FEATURES (cont.):

8. Particle Size and Velocity Distributions. Particles, large enough and/or slow enough to be seen as individual particles, will be photographed and their sizes, velocities, and trajectories will be analyzed. This will enable the particle environment to be modeled, assess the impact of particles on proposed experiments, and possibly, suggest various particle control procedures.
9. Molecular Return Flux. The flux of various molecules being transported to IECM will be measured in conjunction with the MCD measurement to help identify the various transport mechanisms responsible for molecular contamination, and to verify the transport calculations in the models used to predict contamination.
10. Molecular Deposition on an Ambient Surface. The condensible component of the molecular flux will be mapped by measuring molecular deposition on thermally controlled surfaces oriented in different directions. These, along with other data, will be used to check and improve some of the assumptions in the mathematical model used to predict molecular deposition.
11. Molecular Deposition on a Cryogenic Surface. A direct measurement of the molecular deposition on a cryogenic surface will be made and compared with the molecular flux measurements to assess the net effect of all the complexities in attempting to predict the actual deposition from the incident molecular flux.
12. Degradation of Optical Surfaces. A real-time measurement of the degradation of several optical surfaces will be made to determine the relationship between the amount of contaminant deposited and the transmission loss and scattering of the surface. Also, the relative susceptibility of the various surfaces to contamination from the spacecraft environment will be determined.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: Aerosol Count and Size Distribution: sizes ranging from 0.3-1.0, 1.0-5.0, and greater than 5.0 μm; Molecular Column Density: concentrations as low as 10^{10} molecules/cm^2; Background Spectral Intensity: visible and near UV light to intensities fainter than $10^{-14}B_0$; Particle Size and Velocity Distributions: particles as small as 20 μm moving at 1 m/sec (striving for as small as 5 μm to meet specifications); Molecular Return Flux: must be able to measure as few as 10^8 molecules/cm^2/sec/sr; Molecular Deposition on a Cryogenic Surface: must have a collection temperature of 130 K, and sensitivities on the order of 10^{-9} gm/cm^2 to provide time resolutions of tens of minutes.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Project Plan Induced Environment Contamination Monitor (IECM) For Orbital Flight Test (OFT) 1-6 and Long Duration Exposure Facility (LDEF), MSFC, October 1976
Ed Miller, MSFC
R. Gualdoni, NASA HQ, (202) 755-2403

INSTRUMENT: Drop Dynamics Module OI-3

STATUS: Approved **CARRIER**: Spacelab 3 (SL-3)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1 dbl rack **Power Requirement (We)**: 810 (peak)

Mass (kg): 309 **Data Rate (kbps)**: ND

PRINCIPAL PURPOSE AND FEATURES: To conduct experiments to quantitatively measure the figures of free floating drops of liquids to various surface tensions and viscosities under accoustically excited rotation and oscillation. The Drop Dynamics Module consists of areas for program and data tape storage, film magazine storage, chamber clean up materials and waste storage, fluid reservoir and injector storage, control panels, a camera, an oscilloscope, an auxiliary control panel, a magnetic cartridge data system, electronics and power supply, an injector insertion/removal assembly, and accoustic chamber, a liquid pump, and an access door.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Liquid Properties and Ranges
(1) Droplet size - 0.5 to 2.5 cm radius
(2) Viscosity - 1 to 1000 centistokes
(3) Density - 1 to 2 g/cm^3
(4) Surface tension - 10 to 100 dyne/cm
(5) Transmission coefficient - 0.3 to 1 in visible region
(6) Index of refraction - 1.2 to 2.0

Resolution
(1) Spatial - 0.02 cm in linear dimension, 0.2 in internal flow
(2) Temporal - 0.05 Hz in oscillation frequency

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS: Experiments will be conducted under the following conditions.

Rotation
Rotation velocity - 0 to 60 rad/sec ± 0.1 rad/sec
Rotation acceleration - 0.01 to 1 rad/sec^2 ± 0.01 rad/sec^2

Oscillation
Modulation force - maximum of 10 dynes ± 1 dyne as measured at 1.25 cm from center of chamber
Modulation frequency - 0.05 to 30 Hz ± 0.01 Hz linear and exponential sweep
Modulation index - 0 to 100% ± 5%

SOURCE/CONTACT:

Drop Dynamics Module CDR, Von Karman Auditorium, JPL, 6 December 1978
J. Lundholm, NASA HQ, Code RS1

INSTRUMENT: Solar Cell Calibration Facility (SCCF) OI-4

STATUS: Approved

CARRIER: Shuttle/Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.73 × 0.45 × 0.81

Power Requirement (We): 24, 125 (peak)

Mass (kg): 23-24

Data Rate (kbps): NA

PRINCIPAL PURPOSE AND FEATURES:

Verify validity of balloon flight solar cell calibration for present and advanced state-of-the-art solar cells, verify laboratory generated solar cell temperature coefficients, determine cost effectiveness of Spacelab for calibration of solar cells.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SCCF is a self-contained experiment. Experiment size is 44.58 cm x 72.52 cm x 81.28 cm. Experiment automatically gathers data when aligned within 3° half cone angle of true sunline, requires 8 orbits minimum, sun available from end of occultation to start of occultation. Specialist not required. Unit does not require data interface.

SOURCE/CONTACT:

R. Gualdoni, NASA HQ, Code RSS

INSTRUMENT: Tribology

OI-5

STATUS: Approved

CARRIER: Spacelab

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.61 × 0.94 × 0.18

Power Requirement (We): 54, 130 (peak)

Mass (kg): ≤ 68

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

This system consists of seven basic subsystems. They are the fluid wetting and spreading experiments (FWS), the journal bearing experiment (JB), the photographic image recording subsystem, the low-g measurement subsystem, the structural and mechanical subsystem, and the ground support equipment subsystem. It also has three functional objectives: Journal Bearing Experiment. The observation and study of hydro-dynamic films on journal bearings operating in zero gravity; and the measurement of stability in the dynamic bearing system under these conditions. Fluid Wetting and Spreading Experiment. The observation and study of fluid-surface interactions under static conditions in a low gravity environment using commercial lubricants on representative surfaces. Low-g Measurement. The measurement of three axis low-g accelerations.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This is a rack-mounted module intended to be mounted in Rack 7 of Spacelab. Data collection by photographic film and by analog and digital data. Operation by a payload specialist is required.

SOURCE/CONTACT:

Tribological Experiment Assembly Design and Performance End Item Specification
95M12200, Revision B, June 21, 1979
SL1-ERD-INT 011, December 1977
R. Gualdoni, NASA HQ, Code RSS

INSTRUMENT: Miniature Electrostatic Accelerometer (MESA) OI-6

STATUS: Approved

CARRIER: Spacelab-2

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.01 m^3

Power Requirement (We): 20, 0.25 (standby)
20 (peak)

Mass (kg): 7

Data Rate (kbps): 10 (within one orbit)

PRINCIPAL PURPOSE AND FEATURES:

To evaluate Spacelab 2 orbital low-g acceleration environment and to calibrate and evaluate in-orbit performance of the MESA. Three-axis accelerometer is mounted on a rotating table which introduces a variable and controllable centripetal acceleration along the input axis thereby providing signal discrimination relative to noise frequencies. Acceleration measurements along preferred axes possible as well.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

0.1% accuracy without calibration
0.01% accuracy with calibration

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

ER-SL-2 #12 (March 1978)
In Orbit Calibration of MESA Low-g Accelerometer, Bell Aerospace Division of Textron, 3 December 1971
R. Gualdoni, NASA HQ, Code RSS

INSTRUMENT: Superfluid Helium Experiment (SFHE) OI-7

STATUS: Approved **CARRIER:** Shuttle (SL-2)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): ~1.5 m^3 **Power Requirement (We):** 60

Mass (kg): 250 **Data Rate (kbps):** 20 max

PRINCIPAL PURPOSE AND FEATURES: To investigate the thermal and dynamic properties of superfluid helium in zero gravity. The specific objectives of SFHE are to (1) obtain detailed understanding of superfluid helium motions, temperature fluctuations and variations; (2) develop an experimental apparatus to measure capillary surface waves on superfluid films in regime not available in one gravity; (3) demonstrate space operation of a superfluid helium cryostat suitable for technology and scientific experiments, and (4) to obtain detailed information on performance as a guide for future designs.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Bulk Fluid and Thermal Dynamics

Thermal distributions at 12 points - 10 mk differential accuracy
Thermal spectra at 12 points - 1 mk accuracy at 40 Hz bandwidth
- at 10 temperatures in range of 1.5 to 2.2 K

Quantized Surface Wave

Velocity and damping for films of 5 thickness - range of 1 to 10 μm in acceleration field less than 10^{-4}G
- temperature in range of 1.5 to 2.2 K

Waveforms - to 2.5% of film thickness at 80 samples/sec

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS: A flight cryostat contains a supply of superfluid helium in which bulk fluid sensors and quantized surface wave sensors are immersed. Bulk dynamics and temperature distribution data will be taken during and shortly after Shuttle maneuvers while quantized surface wave measurements will be made during quiescent periods. A dedicated experiment processor controls the instrument and transmits data to ground via the CDMS. Payload specialist required only for turn-on, turn-off, and general monitoring.

SOURCE/CONTACT:

Superfluid Helium Experiment Preliminary Design Review, JPL, 5 December 1978
ER-SL-2 #13
J. Lundholm, NASA HQ, Code RSI

INSTRUMENT: Thermal Canister OI-8

STATUS: Approved

CARRIER: Space Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 1 × 1 × 3

Power Requirement (We):

Mass (kg): 160

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: To demonstrate the performance in space of an Experimental Thermal Control Canister using heat pipes. The thermal canister system consists of four subsystems, namely, a mechanical system, a thermal system, an electrical system, and a data system.

The mechanical system will be mounted in the bay on either an ESA type pallet or through a support plate to a DFI type structure, depending upon availability. Structural hardpoints will be provided at a center support frame or at one end of the canister. Internally, provisions will be made to tie in instrument mass simulators, or suitable instrument packages, so as to determine thermal response during experimental modes. The construction will be modular at the heat pipe, panel, and radiator level so that these elements can be removed and replaced with new technology heat pipes on later flights.

The thermal system makes use of active feedback variable conductance (VCHP) and isothermalizer heat pipes. The heat generated in the instrument simulators within the canister is either conducted or radiated to the walls where it is transferred via heat pipes to the variable conductance heat pipes attached to the radiators. By sensing variations in the temperature of the wall or in the instrument simulator, primarily due to power variations, reservoir heaters can be actuated, via a controller, to modulate heat flow from the radiators.

As for the electrical system, some of the services required to operate the experiment come directly from shuttle or through shuttle via the down-link. This includes power, data storage, commanding and payload monitoring. Self-contained within the Canister Experiment are signal conditioning, power regulation (if required), an additional data-storage system, controllers, and/or microprocessors.

In the data system, data will be stored on a canister tape recorder. If TDRSS is available, the Ku-band downlink data capability will be used to achieve near real-time coverage. The data storage system will be supplied by the experiment, similar to the IECM system being developed at MSFC, to augment the shuttle tape recorder capability.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

Temperature level can be adjusted over a range of 5 to 25°C and can be maintained to within 3°C of the selected temperature through the use of a set-point controller or microprocessor.

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

SOURCE/CONTACT:

Execution Phase Project Plan for Thermal Canister Experiment, May 1977
R. Gualdoni, NASA HQ, Code RSS

INSTRUMENT: Infrared Materials - Semiconductor Materials Growth in Low-g Environment

OI-9

STATUS: Approved

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): $\sim 3\ m^3$

Power Requirement (We): 4.7 kW

Mass (kg): 1100 kg

Data Rate (kbps): 16 kHz

PRINCIPAL PURPOSE AND FEATURES:

To investigate the effect of micro-gravity on the growth of component semiconductor crystals. Expected effects are the reduction or elimination of both micro- and macro-segregation of components.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

The crystals will be evaluated upon return to earth. Instrumentation in space will include:

Temperature measurement: 9 positions, ±0.5°C
Acceleration: 0-50 Hz
Sample position: ±0.1 mm accuracy
Sample speed: ±1% accuracy

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

This experiment is one part of the multi-experiment program, Materials Processing in Space, managed by MSFC.

SOURCE/CONTACT: J. Lundholm, NASA HQ, Code RSI; A. Fripp, LaRC, (804) 827-3661;
RTOP 542-03-30

INSTRUMENT: Long Duration Exposure Facility (LDEF) 0I-10

STATUS: Approved

CARRIER: Free-Flyer

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): ≈9.14 × 4.27 (dia)

Power Requirement (We): None

Mass (kg): ≈4500 (experiments included)

Data Rate (kbps): None

PRINCIPAL PURPOSE AND FEATURES: The LDEF is a reusable, unmanned, low cost, free-flying structure on which many different passive experiments can be mounted. The facility will be delivered to earth orbit by the shuttle. After an extended period in orbit, the facility will be retrieved on a subsequent shuttle flight and returned to earth for experiment analysis. The free-flying feature distinguishes LDEF missions from Spacelab and Pallet missions in which the experiments and the Spacelab and/or Pallet remain in the shuttle cargo bay. The main project objectives are: (1) to develop a simple, low cost, free-flying facility for performing long duration technology and other experiments in the space environment using the STS; (2) to develop a low cost set of experiments for the facility, demonstrate Shuttle/LDEF capabilities and features, and obtain valuable technological and other data; (3) to broaden the STS user community by providing a simple low cost approach for performing a large number of OAST and other unmanned long duration space experiments via the STS when operational.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

COMMENTS:

The primary LDEF structure consists of a framework of equally spaced ring frames and longerons. The experiment trays are removable to facilitate experiment preparation, handling and data analysis. The structure will have attachment fittings to secure it to the shuttle bay, and will be configured for gravity-gradient stabilization. The LDEF will have no active thermal control system; individual experiments will have to rely on their own thermal control processes.

SOURCE/CONTACT:

Long Duration Exposure Facility (LDEF) Project Plan, LaRC, June 1974
R. Gualdoni, NASA HQ, Code RSS

INSTRUMENT: 8 cm Ion Engine Demonstration OI-11

STATUS: Approved

CARRIER: P80-1 DoD S/C
900 km, 73°

DATES: Launch 1982

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.59 × 0.59 × 0.50 (without support structure)

Power Requirement (We): 205

Mass (kg): 27

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES:

To obtain charged particle and neutral particle material transport data that cannot be obtained in earth based facilities and to establish flight worthiness of 8 cm mercury ion thrusters. Package consists of a cubic box with 2 ion thrusters. Box contains power conditioning equipment, a digital interface unit, diagonostic instruments, and a thermal control interface.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

1. Quartz crystal microbalance measures submonolayer amounts of deposition.
2. Potential probe measures spacecraft potential relative to space plasma with range of +25 to -175 V.
3. Ion collectors measure incident ion flux and have energy discrimination.
4. Performance of warm and cold solar cells and radiators are measured to detect possible degradation effects due to ion engine operation.
5. Performance of several components of ion engine are monitored.

ASSOCIATED RANGES AND/OR RESOLUTION:

Thrust level: 1.12 mlb (4.98 mN), I_{sp} = 2750 sec, power to thruster, 125 W; 72% electrical, 77% propellant, 55% overall electrical to thrust efficiency; 72 mamp beam current; net acceleration voltage, 1250 V; propellant flow, 0.7 g/hr; propellant carried, 8.75 kg; power electronics unit is 39 × 20 × 11 cm, 7.5 kg, 160 W electrical output and 40 W conversion loss heat.

COMMENTS:

Planned thruster tests over the 3 year S/C life will consist of 2500 off-on cycles totalling 7000 hr of operation. If successful operation is achieved, this type of system could be used for north-south station keeping of a 1500 kg geostationary payload, saving 110 kg compared with a hydrazine system over a 7 yr life.

SOURCE/CONTACT:

R. Gualdoni, NASA HQ, Code RSS
NASA CR-135275

INSTRUMENT: SEP Solar Array Shuttle Flight Experiment OI-12

STATUS: Approved

CARRIER: Shuttle

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 12.7 m^3

Power Requirement (We): 140,530 (peak)

Mass (kg): 409

Data Rate (kbps): 10.56 (ascent/entry)
5.28 (orbit ops)

PRINCIPAL PURPOSE AND FEATURES: Provide space demonstration of advanced lightweight solar array technology which meets the requirements of solar electric propulsion (SEP) and shuttle payload applications. Specific objectives include: demonstration of array structural integrity in shuttle environments, full and partial retraction and stowage; demonstration of proper array performance in thermal, vacuum and zero-gravity environment; correlation of performance predictions.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION: Experiment wing performance requirements: 25 kW SEP solar array, wing wt to be 225 kg; capable of operation in geosynchronous and low earth orbits and from 0.3 A.U. to 6.0 A.U. from the sun; 5-year life in space and 2-year storage life; 50 extension/partial retraction/full retraction cycles; partial extension position at 75% of full length; 3 electrical modules (360 W) and remaining 79 modules to use mass simulators for solar cell areas; experiment capable of measuring any electrical degradation.

ASSOCIATED RANGES AND/OR RESOLUTION: Instrumentation complement includes:

Sun sensor - resolution: ±1.5° from sun normal
Accelerometers - resolution: 1×10^{-6} g
Film camera (cargo bay in view of experiment) - speed: 10 frames/sec
Temperature sensors (17) - range: 144-533 K
resolution: ±2%
Voltage sensor (10)
Solar panel current monitors (6)
Data acquisition system
Tape recorder - capacity: 1.44×10^8 bits; error rate: <1 in 10^6 bits

COMMENTS:

One SEP solar array wing will be extended and retracted several times over a wide range of temperature conditions. The extended array wing will be mechanically excited so that wing dynamics (frequencies and modes) can be measured. Thermal and electrical performance will be measured. Payload specialist required to operate experiment package, monitor its status, and turn TV and film cameras on and off.

SOURCE/CONTACT:

J. DiBattista, NASA HQ, Code RSS
Preliminary ERD (LMSC-D573763)

INSTRUMENT: ASPS Vernier System (AVS) OI-13

STATUS: Approved **CARRIER**: Shuttle (Pallet)

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m): 0.92 m^3

Power Requirement (We): 320; 1330 (Peak)
307 (Standby)

Mass (kg): 303

Data Rate (kbps): 3 HRM and 3 RAU max

PRINCIPAL PURPOSE AND FEATURES:

To demonstrate a state-of-the-art vernier pointing system in an orbital environment.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:

Pointing specifications (assuming ideal inertial sensors):

LOS accuracy: $\pm 4.8 \times 10^{-4}$ mrad
LOS disturbance response: $\pm 4.8 \times 10^{-5}$ mrad
Roll accuracy: $\pm 4.8 \times 10^{-3}$ mrad
Roll rate stability: $\pm 4.8 \times 10^{-3}$ mrad/s

COMMENTS:

Pointing mount. Flight package consists of a complete pointing mount combining a magnetically suspended fine pointing subsystem, the ASPS Vernier System (AVS), with a mechanically hinged pointing subsystem, the ASPS Gimbal System (AGS). A dedicated digital computer and associated electronics controls both pointing functions. Pointing system contains sun sensor, star tracker, and inertial reference.

SOURCE/CONTACT:

J. Lundholm, NASA HQ, Code RSI , 202/755-2413

INSTRUMENT: Propulsion Contamination Effects Module (PCEM) OI-14

STATUS: Planned

CARRIER: Shuttle Orbiter

PHYSICAL AND GENERAL PROPERTIES:

Physical Size (m):

Power Requirement (We): 1000-2000

Mass (kg): 550-2330

Data Rate (kbps):

PRINCIPAL PURPOSE AND FEATURES: The principal objective of the PCEM Program is to determine the effects of plumes from various types of thrusters under actual space conditions and to utilize the data thus obtained to build a predictive capability covering these effect. The PCEM Facility instrument measurement systems will be used to measure backflow efflux (mass and constituents), electrical charge buildup, and impingement forces and heating rates. The recorded experimental data will be added to the existing data base to determine the ability of analytical models to predict these same effects.

A secondary objective is to characterize the propulsion system in the space environment. The PCEM Facility will accommodate propulsion systems instrumented for performance characterization data.

The principal design objective for the PCEM Facility Project is to design and develop the facility for integration with the propulsion systems and for flight of the PCEM system in the payload bay of the Space Shuttle Orbiter.

Included as instruments on board the facility are temperature-controlled quartz crystal microbalances (QCM), a mass spectrometer, electric charge measurement instruments, and pressure and temperature instruments.

PRINCIPAL PHYSICAL PROPERTY MEASURED, RANGE, ACCURACY, AND RESOLUTION:

ASSOCIATED RANGES AND/OR RESOLUTION:
The facility will have the capability of testing rocket propulsion systems at steady state thrust levels up to 4450 N (1000 lbf).

COMMENTS: The PCEM Facility will be designed to initially accommodate the MSFC 110 N (25 lbf) monopropellant hydrazine propulsion system which is the first representative of this class of experiments. Design modification kits will enable the PCEM Facility to accommodate other propulsion system concepts, including a 3870 N (870 lbf) N_2O_4/MMH liquid bipropellant rocket engine, 4.4×10^{-3} N (1×10^{-3} lbf) and 1.3×10^{-1} N (3×10^{-2} lbf) ion drive engines, a 4150 N (930 lbf) solid rocket motor (SRM), and an O_2/H_2 bipropellant system, as well as other similar types of propulsion systems. The PCEM is in a planning stage today. This descriptionshould be treated as generic, not final.

SOURCE/CONTACT:
730-46 Project Plan Propulsion Contamination Effects Module (PCEM) - Spaceflight Experiment Facility, L.F. Molinari, 21 February 1979
R. Gualdoni, NASA HE, Code RSS

PART C: TECHNOLOGY REQUIREMENTS SUMMARY

This portion of Volume I of the NASA Space Systems Technology Model presents a summary of the technology requirements data contained in all mission system and program descriptions within the earlier sections. The intent is to provide a convenient method for ascertaining the demands upon each technology discipline. The data are presented in tabular form by discipline, and where possible are plotted as a function of start date.

The technology disciplines include: power and electric propulsion; chemical propulsion; materials and structures; information systems; navigation, guidance and control; and automated operations.

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POWER AND ELECTRIC PROPULSION

Average Power Consumed

Peak Power Consumed

Electric Propulsion - Thrust Level

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POWER

Average Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	0.4	1979
A-1	High Energy Astronomy Observatory-C	0.365	1979
A-2	Infrared Astronomical Satellite (IRAS)	0.2	1979
A-3	Space Telescope	2.1	1979
S-1	Solar Maximum Mission	0.73	1979
S-2	Dynamics Explorer	0.055	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	<2.5	1979
R-1	Magsat	0.12-0.16	1979
R-2	Landsat D	0.75	1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	0.029-0.082	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)	0.320	1979
E-3	Solar Mesosphere Explorer (SME)	0.135	1979
E-5	NOAA A-G	0.460	1979
E-4	Earth Radiation Budget Satellite	0.109	1979
C-1	Tracking & Data Relay Satellite System (TDRSS)	1.8	1979
C-2	Search and Rescue Mission	0.093	1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

POWER

Average Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle	7.0	1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	0.25-1.2	1979
U-2	Spacelab	2.5-5.5	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	0.25	1980
S-4	Solar Optical Telescope (SOT)	0.935	1980
S-5	Chemical Release Module Facility	0.02	1980
A-5	Extreme Ultraviolet Explorer	0.07	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	0.4	1981
A-7	Gamma Ray Observatory (GRO)	2.0	1981
S-6	Active Magnetospheric Particle Tracer Experiment	0.12	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	0.145	1981
E-6	National Oceanic Satellite System (NOSS)	2.2	1981
T-9	Solar Electric Propulsion	25.0	1981
U-4	Tethered Satellite System	0.121	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package	0.2	1981

POWER

Average Power Consumed (kWe)

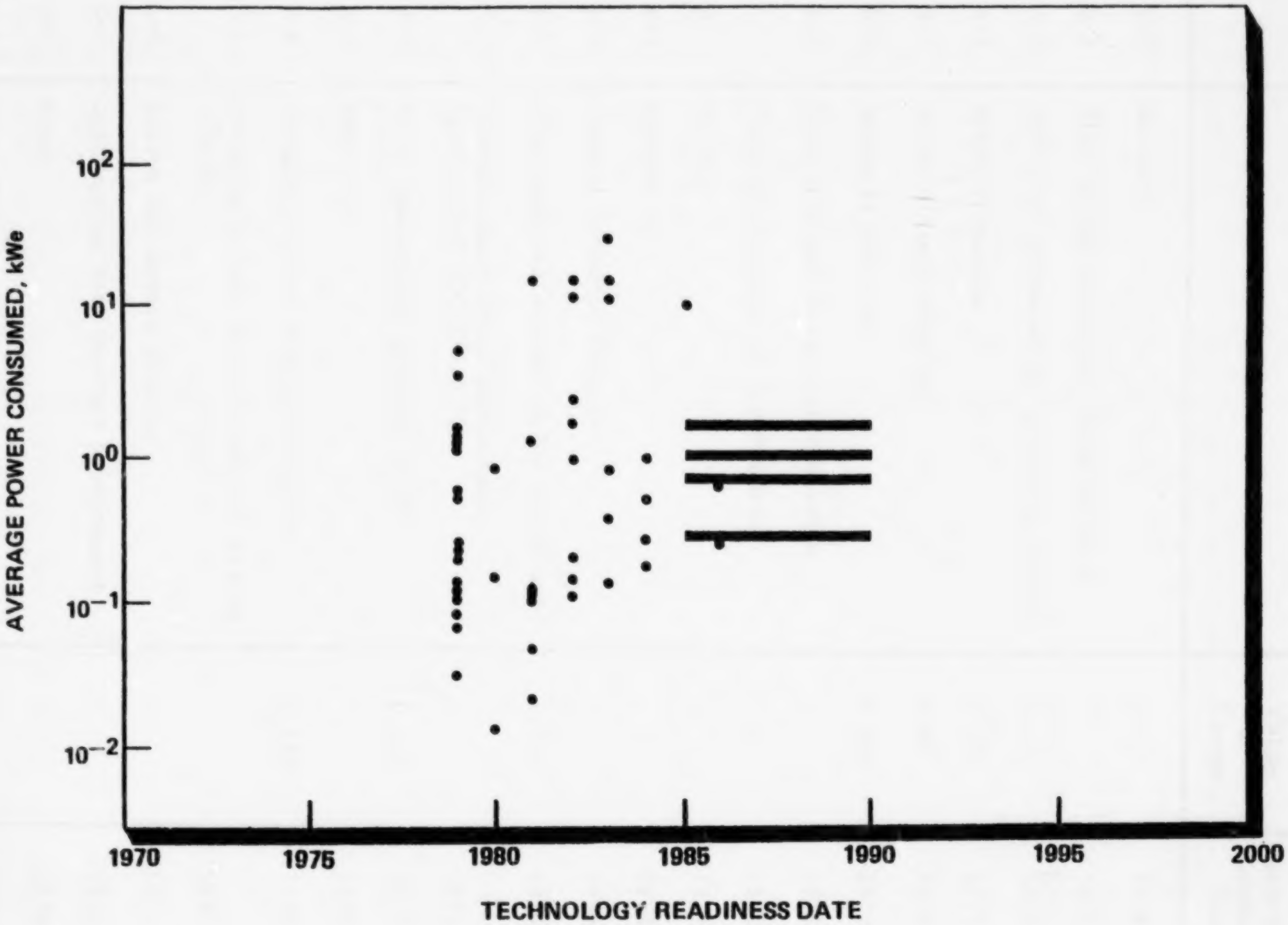
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	1.0	1982
P-3	International Comet Mission	0.35	1982
A-8	Gravity Probe B (GP-B)	0.225	1982
S-8	Solar Soft X-Ray Telescope	0.24	1982
L-2	Space Sciences Platform	15.0	1982
R-4	Gravsat A	0.15	1982
E-7	Upper Atmospheric Research Satellite (UARS)	1.0	1982
E-8	NOSS Research Program	2.7	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program	1-4.2	1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform	25.0	1982
A-9	Advanced X-Ray Astrophysics Facility	0.9	1983
A-10	X-Ray Timing Explorer	0.6	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration	25-50	1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System	25.0	1983
U-9	Materials Experimentation Carrier	15.0	1983
S-9	Subsatellite Facility	0.2	1983

POWER

Average Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	0.45	1984
P-5	Mars Advanced Technology (Sample Return)	0.3	1984
A-11	Starlab	1.0	<1984
S-11	Solar Probe	0.7	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	10.5	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment	0.23-1.2	Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	0.5	1985-1990
A-17	Large Ambient Deployable IR Telescope	<3.0	1985-1990
P-6	Uranus, Neptune, Pluto Program	0.45	1986
S-13	Solar Cycle and Dynamics Mission	0.8	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	0.85	<1990
A-13	Cosmic Ray Observatory	1.075	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	1.05	<1990
A-15	Very Long Base-Line Radio Interferometer		<1990
U-11	Large Power Module	200-500	1990

TECHNOLOGY REQUIREMENTS SUMMARY



Power: Average Power Consumed

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POWER

Peak Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	0.42	1979
A-1	High Energy Astronomy Observatory-C		1979
A-2	Infrared Astronomical Satellite (IRAS)	0.364	1979
A-3	Space Telescope	2.367	1979
S-1	Solar Maximum Mission	2.88	1979
S-2	Dynamics Explorer	0.085	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	6.5	1979
R-1	Magsat		1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	0.082	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	0.160	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite	0.195	1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

POWER

Peak Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle	30.0	1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	2.0	1979
U-2	Spacelab	8-9	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)		1980
S-4	Solar Optical Telescope (SOT)		1980
S-5	Chemical Release Module Facility	0.18	1980
A-5	Extreme Ultraviolet Explorer	0.11	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)		1981
A-7	Gamma Ray Observatory (GRO)	2.0	1981
S-6	Active Magnetospheric Particle Tracer Experiment		1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)		1981
E-6	National Oceanic Satellite System (NOSS)	ND	1981
T-9	Solar Electric Propulsion		1981
U-4	Tethered Satellite System	1.128	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package	26.0	1981

POWER

Peak Power Consumed (kWe)

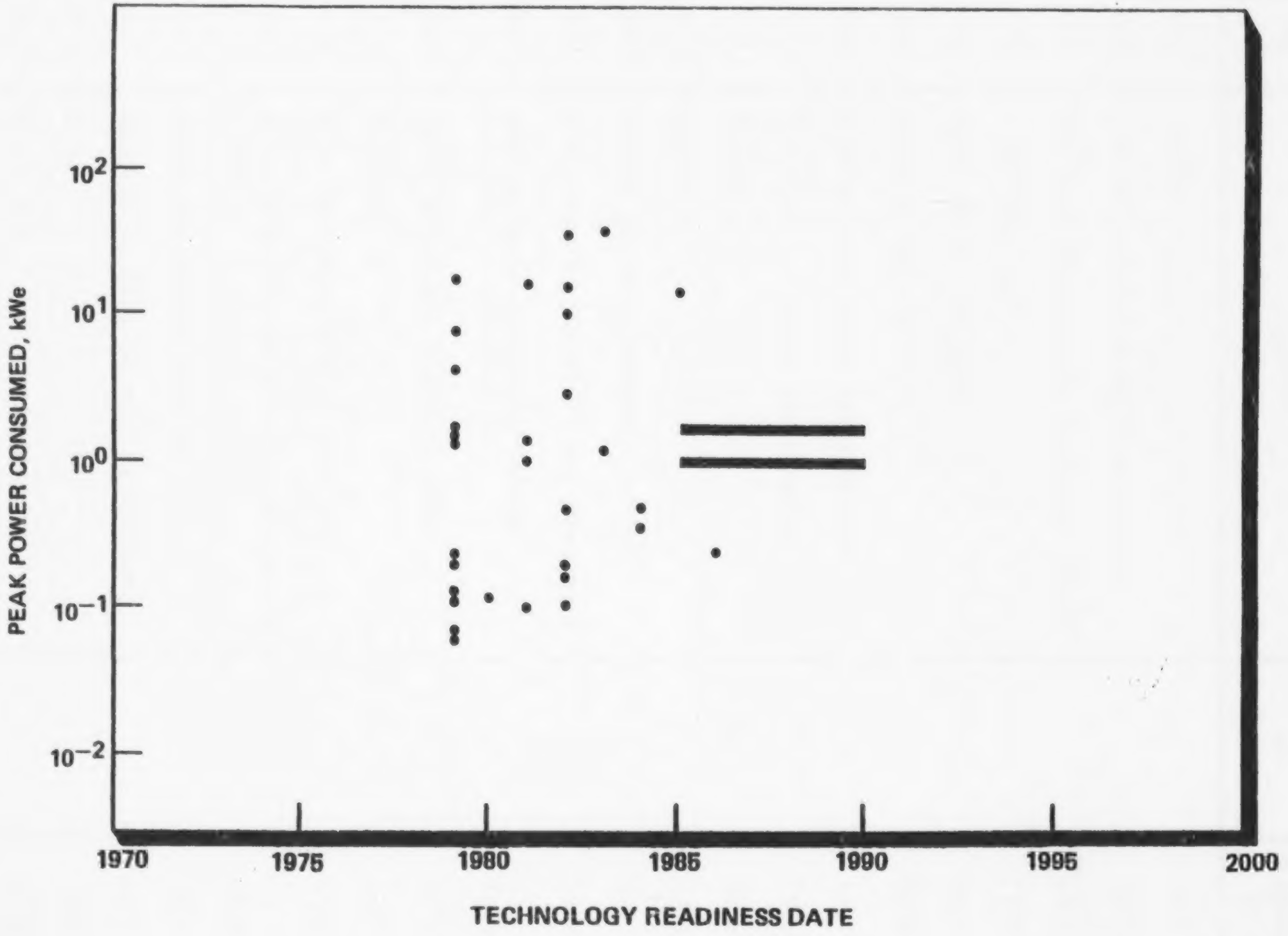
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar		1982
P-3	International Comet Mission	0.7	1982
A-8	Gravity Probe B (GP-B)	0.27	1982
S-8	Solar Soft X-Ray Telescope	0.36	1982
L-2	Space Sciences Platform	25.0	1982
R-4	Gravsat A	0.150	1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program	5.0	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program	11.0	1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform	59.0	1982
A-9	Advanced X-Ray Astrophysics Facility		1983
A-10	X-Ray Timing Explorer	1.5	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System	59.0	1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility		1983

POWER

Peak Power Consumed (kWe)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	0.6	1984
P-5	Mars Advanced Technology (Sample Return)		1984
A-11	Starlab		<1984
S-11	Solar Probe	0.7	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	25.0	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment	3.0 for 10 min	Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	1.0	1985-1990
A-17	Large Ambient Deployable IR Telescope		1985-1990
P-6	Uranus, Neptune, Pluto Program	0.45	1986
S-13	Solar Cycle and Dynamics Mission		1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory		<1990
A-13	Cosmic Ray Observatory		<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)		<1990
A-15	Very Long Base-Line Radio Interferometer		<1990
U-11	Large Power Module		1990

TECHNOLOGY REQUIREMENTS SUMMARY



Power: Peak Power Consumed

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ELECTRIC PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo		1979
A-1	High Energy Astronomy Observatory-C		1979
A-2	Infrared Astronomical Satellite (IRAS)		1979
A-3	Space Telescope		1979
S-1	Solar Maximum Mission		1979
S-2	Dynamics Explorer		1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments		1979
R-1	Magsat	NA	1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment		1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	NA	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite		1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

ELECTRIC PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle		1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft		1979
U-2	Spacelab		1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)		1980
S-4	Solar Optical Telescope (SOT)		1980
S-5	Chemical Release Module Facility		1980
A-5	Extreme Ultraviolet Explorer		1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)		1981
A-7	Gamma Ray Observatory (GRO)		1981
S-6	Active Magnetospheric Particle Tracer Experiment		1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)		1981
E-6	National Oceanic Satellite System (NOSS)		1981
T-9	Solar Electric Propulsion	<1	1981
U-4	Tethered Satellite System		1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package		1981

ELECTRIC PROPULSION

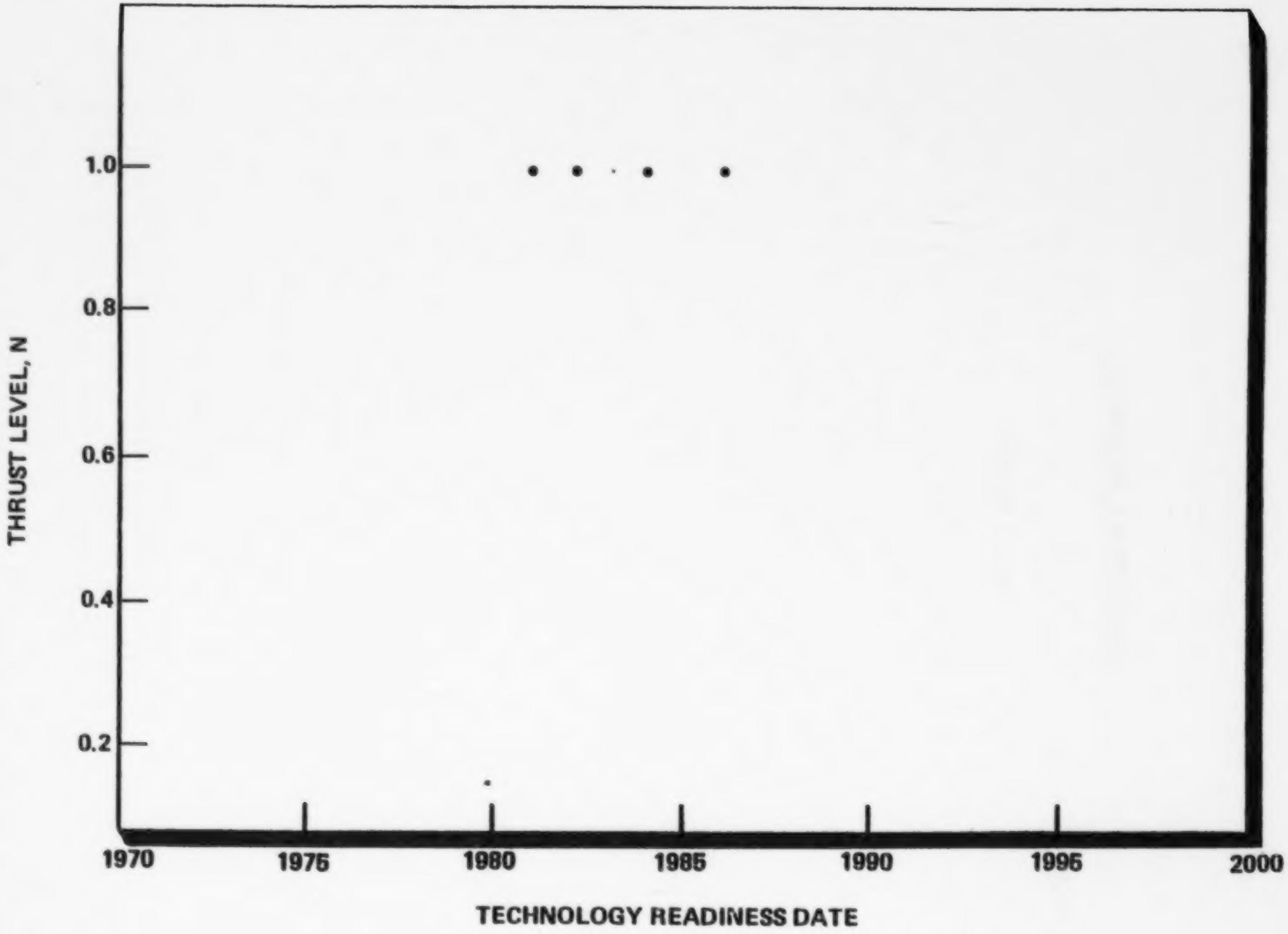
Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar		1982
P-3	International Comet Mission	<1	1982
A-8	Gravity Probe B (GP-B)		1982
S-8	Solar Soft X-Ray Telescope		1982
L-2	Space Sciences Platform		1982
R-4	Gravsat A		1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program		1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program		1982
T-11	Teleoperator Retrieval System		1982
U-7	Science & Applications Space Platform		1982
A-9	Advanced X-Ray Astrophysics Facility		1983
A-10	X-Ray Timing Explorer		1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System		1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility		1983

ELECTRIC PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	<1	1984
P-5	Mars Advanced Technology (Sample Return)		1984
A-11	Starlab		<1984
S-11	Solar Probe		1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory		1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope		1985-1990
A-17	Large Ambient Deployable IR Telescope		1985-1990
P-6	Uranus, Neptune, Pluto Program	<1	1986
S-13	Solar Cycle and Dynamics Mission		1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory		<1990
A-13	Cosmic Ray Observatory		<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)		<1990
A-15	Very Long Base-Line Radio Interferometer		<1990
U-11	Large Power Module		1990



Electric Propulsion: Thrust Level

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CHEMICAL PROPULSION

Thrust Level

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CHEMICAL PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	10-400	1979
A-1	High Energy Astronomy Observatory-C		1979
A-2	Infrared Astronomical Satellite (IRAS)	NA	1979
A-3	Space Telescope		1979
S-1	Solar Maximum Mission	NA	1979
S-2	Dynamics Explorer	NA	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments		1979
R-1	Magsat	NA	1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment		1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	NA	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite		1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout	Stage 1. 485117 2. 285610 3. 83100 4. 25623	1979
T-2	Delta 3914	3.883×10^6, 1.0217×10^6, 44190, 61855	1979
T-3	Atlas-F	8.56×10^5, 3.65×10^5	1979

CHEMICAL PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur	9.23×10^5, 3.67×10^5, 6.56×10^4	1979
T-5	Space Shuttle	3870, 111, 267000, 12.9×10^6, 1.67×10^6	1979
T-6	Spinning Solid Upper Stage	3.43×10^5, 1.47×10^5	1979
T-8	Inertial Upper Stage (IUS)	1.93×10^5, 78053	1979
T-7	Multimission Modular Spacecraft	22	1979
U-2	Spacelab		1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	ND	1980
S-4	Solar Optical Telescope (SOT)		1980
S-5	Chemical Release Module Facility	27090	1980
A-5	Extreme Ultraviolet Explorer	ND	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	NA	1981
A-7	Gamma Ray Observatory (GRO)		1981
S-6	Active Magnetospheric Particle Tracer Experiment	2613 (1st stg) 378 (2nd stg)	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	23-1000	1981
E-6	National Oceanic Satellite System (NOSS)	0.9(con. tor) 2.2(ΔV changes)	1981
T-9	Solar Electric Propulsion		1981
U-4	Tethered Satellite System	NA	1981
U-5	Large Space Structures Technology and Development Program	NA	1981
U-6	Power Extension Package		1981

CHEMICAL PROPULSION

Thrust Level (N)

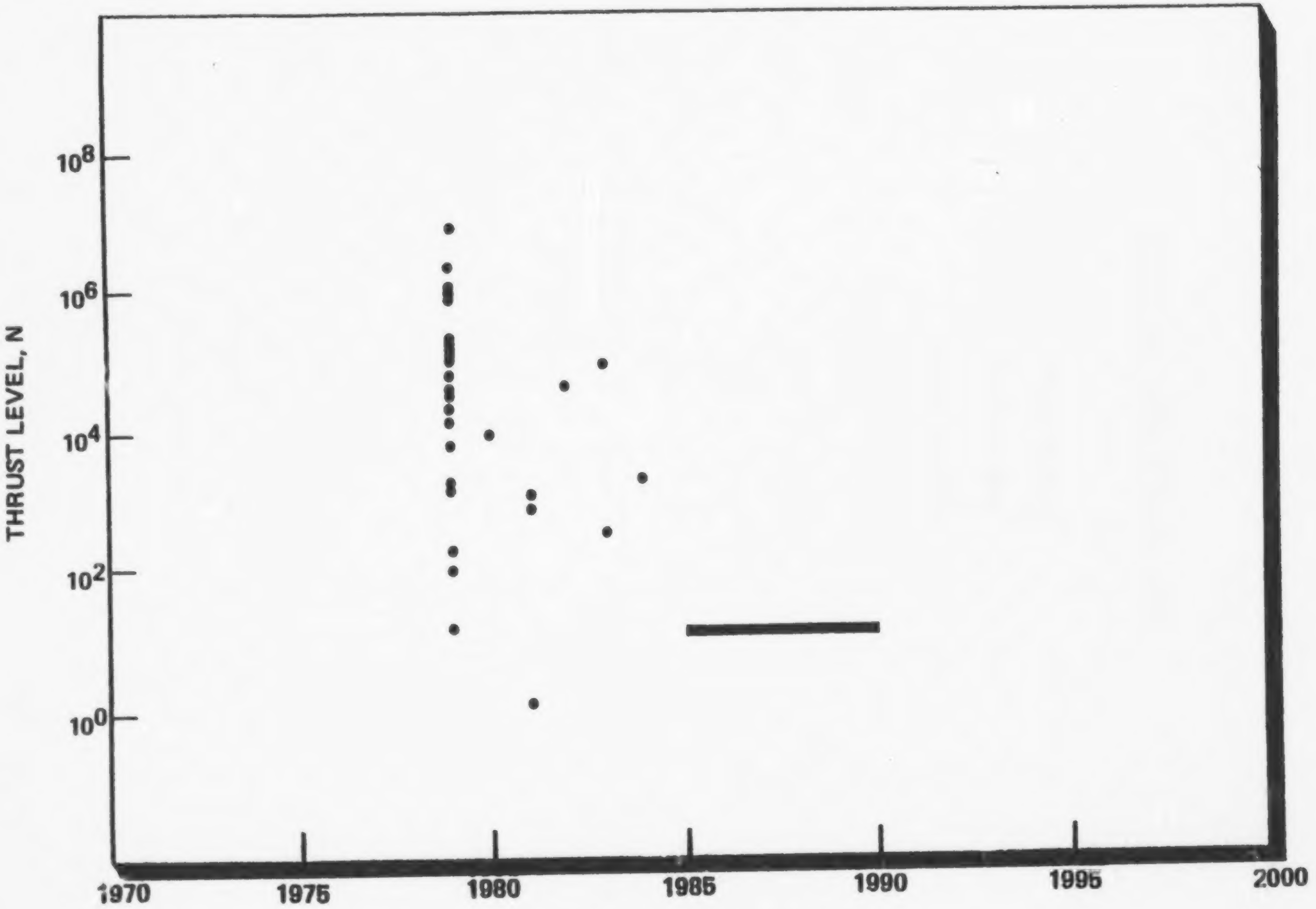
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	6.7×10^4 (1st Stage) 6.2×10^4 (2nd Stage)	1982
P-3	International Comet Mission	NA	1982
A-8	Gravity Probe B (GP-B)	NA	1982
S-8	Solar Soft X-Ray Telescope	NA	1982
L-2	Space Sciences Platform		1982
R-4	Gravsat A		1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program		1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program		1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform		1982
A-9	Advanced X-Ray Astrophysics Facility	NA	1983
A-10	X-Ray Timing Explorer	250	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle	65000-80000	1983
U-8	25-kW Power System	TBD	1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility	SD	1983

CHEMICAL PROPULSION

Thrust Level (N)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	ND	1984
P-5	Mars Advanced Technology (Sample Return)		1984
A-11	Starlab	NA	<1984
S-11	Solar Probe	3558	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	NA	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment	11	Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	NA	1985-1990
A-17	Large Ambient Deployable IR Telescope	ND	1985-1990
P-6	Uranus, Neptune, Pluto Program	ND	1986
S-13	Solar Cycle and Dynamics Mission	ND	1986
T-12	Manned GEO Sortie	ND	1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	ND	<1990
A-13	Cosmic Ray Observatory		<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	ND	<1990
A-15	Very Long Base-Line Radio Interferometer	ND	<1990
U-11	Large Power Module		1990

TECHNOLOGY REQUIREMENTS SUMMARY



TECHNOLOGY READINESS DATE

Chemical Propulsion: Thrust Level

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MATERIALS AND STRUCTURES

Total Mass

Physical Size

Flight Duration

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MATERIALS

Total Mass (kg)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	2060	1979
A-1	High Energy Astronomy Observatory-C	2900	1979
A-2	Infrared Astronomical Satellite (IRAS)	1019	1979
A-3	Space Telescope	11,070	1979
S-1	Solar Maximum Mission	2315	1979
S-2	Dynamics Explorer	424	1979
S-3	International Solar Polar Mission	ND	1979
L-1	Spacelab Biological Experiments	14,000	1979
R-1	Magsat	174	1979
R-2	Landsat D	1597	1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	147	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)	720	1979
E-3	Solar Mesosphere Explorer (SME)	155	1979
E-5	NOAA A-G	740	1979
E-4	Earth Radiation Budget Satellite	TBD	1979
C-1	Tracking & Data Relay Satellite System (TDRSS)	1905	1979
C-2	Search and Rescue Mission	850	1979
C-3	Application Data Service Development		1979
T-1	Scout	21,396	1979
T-2	Delta 3914	169.045	1979
T-3	Atlas-F	118,448	1979

MATERIALS

Total Mass (kg)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur	148,350	1979
T-5	Space Shuttle	86,000	1979
T-6	Spinning Solid Upper Stage	2155(SSUS-D) 3788(SSUS-A)	1979
T-8	Inertial Upper Stage (IUS)	10886(SRM-1) 3856(SRM-2)	1979
T-7	Multimission Modular Spacecraft	1220(Mark-I) 4048(Mark II)	1979
U-2	Spacelab	4800-9400	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	1421	1980
S-4	Solar Optical Telescope (SOT)	3100	1980
S-5	Chemical Release Module Facility	2700	1980
A-5	Extreme Ultraviolet Explorer	400	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	2950	1981
A-7	Gamma Ray Observatory (GRO)	11,000	1981
S-6	Active Magnetospheric Particle Tracer Experiment	770	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	1000	1981
E-6	National Oceanic Satellite System (NOSS)	3816-5150	1981
T-9	Solar Electric Propulsion	3400	1981
U-4	Tethered Satellite System	1500	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package	950	1981

MATERIALS

Total Mass (kg)

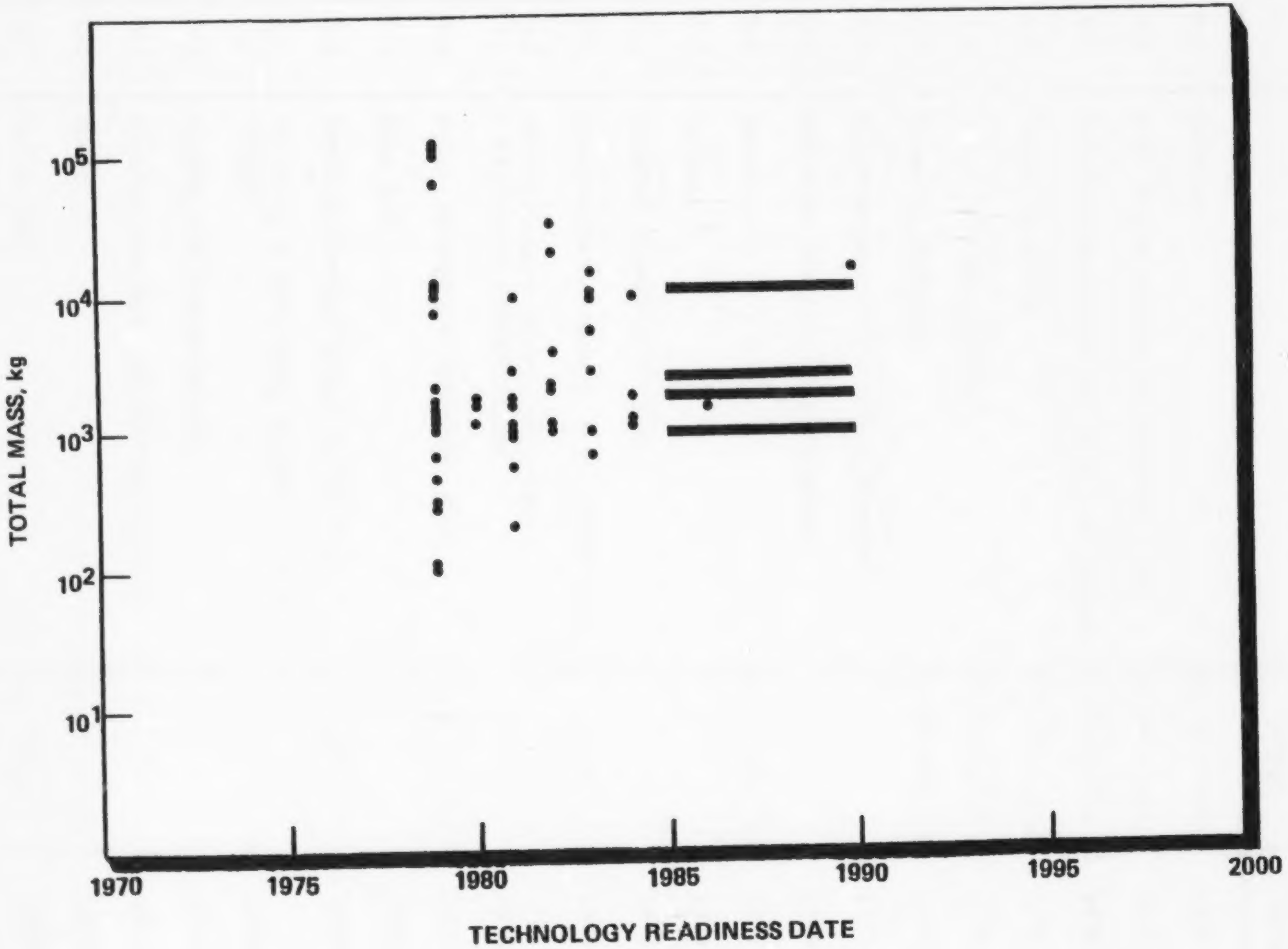
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	1000	1982
P-3	International Comet Mission	3800	1982
A-8	Gravity Probe B (GP-B)	1270	1982
S-8	Solar Soft X-Ray Telescope	1300	1982
L-2	Space Sciences Platform	60,000	1982
R-4	Gravsat A	4000	1982
E-7	Upper Atmospheric Research Satellite (UARS)	ND	1982
E-8	NOSS Research Program	4186	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program	1000 & 1250	1982
T-11	Teleoperator Retrieval System	5600-6500	1982
U-7	Science & Applications Space Platform	25,000-40,000	1982
A-9	Advanced X-Ray Astrophysics Facility	10,000	1983
A-10	X-Ray Timing Explorer	850	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration	5000-8000	1983
T-10	Orbital Transfer Vehicle	$\leq$28,000	1983
U-8	25-kW Power System	13,967	1983
U-9	Materials Experimentation Carrier	5000	1983
S-9	Subsatellite Facility	200-1000	1983

MATERIALS

Total Mass (kg)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	3600	1984
P-5	Mars Advanced Technology (Sample Return)	3000-10,000	1984
A-11	Starlab	2000	<1984
S-11	Solar Probe	1500	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	ND	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	1000	1985-1990
A-17	Large Ambient Deployable IR Telescope	16,000	1985-1990
P-6	Uranus, Neptune, Pluto Program	600-1000	1986
S-13	Solar Cycle and Dynamics Mission	2600	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	3000-3500	<1990
A-13	Cosmic Ray Observatory	18,000	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	5200	<1990
A-15	Very Long Base-Line Radio Interferometer	ND	<1990
U-11	Large Power Module	29,230	1990

TECHNOLOGY REQUIREMENTS SUMMARY



Materials and Structures: Total Mass

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STRUCTURES

Physical Size (m)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	5.1×4.4 dia	1979
A-1	High Energy Astronomy Observatory-C	5.4×2.7 dia	1979
A-2	Infrared Astronomical Satellite (IRAS)	3.6×1.6 dia	1979
A-3	Space Telescope	13.6×4.3 dia	1979
S-1	Solar Maximum Mission	4.0×2.3 dia	1979
S-2	Dynamics Explorer	1.15×1.35 di	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	15×4.5	1979
R-1	Magsat	1.55×~0.5 dia	1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	1.45	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	1.1×0.9 dia	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite	TBD	1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout	22.5 length	1979
T-2	Delta 3914	33 height	1979
T-3	Atlas-F	30 length	1979

STRUCTURES

Physical Size (m)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur	38	1979
T-5	Space Shuttle	37×17×24	1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)	5 (length 2 stage) 6.7 (length twin stage) 2.4 (length twin spinner)	1979
T-7	Multimission Modular Spacecraft	1.7×2 Mark-I 2.9×3.6 Mark-II	1979
U-2	Spacelab	7×4.2 dia	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	4.8×4.4	1980
S-4	Solar Optical Telescope (SOT)	7.3×3.9 dia	1980
S-5	Chemical Release Module Facility	2×3 dia	1980
A-5	Extreme Ultraviolet Explorer	4.5	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	8.7×3.1 dia	1981
A-7	Gamma Ray Observatory (GRO)	6×4.5 dia	1981
S-6	Active Magnetospheric Particle Tracer Experiment	1.1×3 dia	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	3.5×3.0 dia	1981
E-6	National Oceanic Satellite System (NOSS)	10.7×4.5 dia	1981
T-9	Solar Electric Propulsion	4×75	1981
U-4	Tethered Satellite System	3.8×3.6×12.4	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package		1981

STRUCTURES

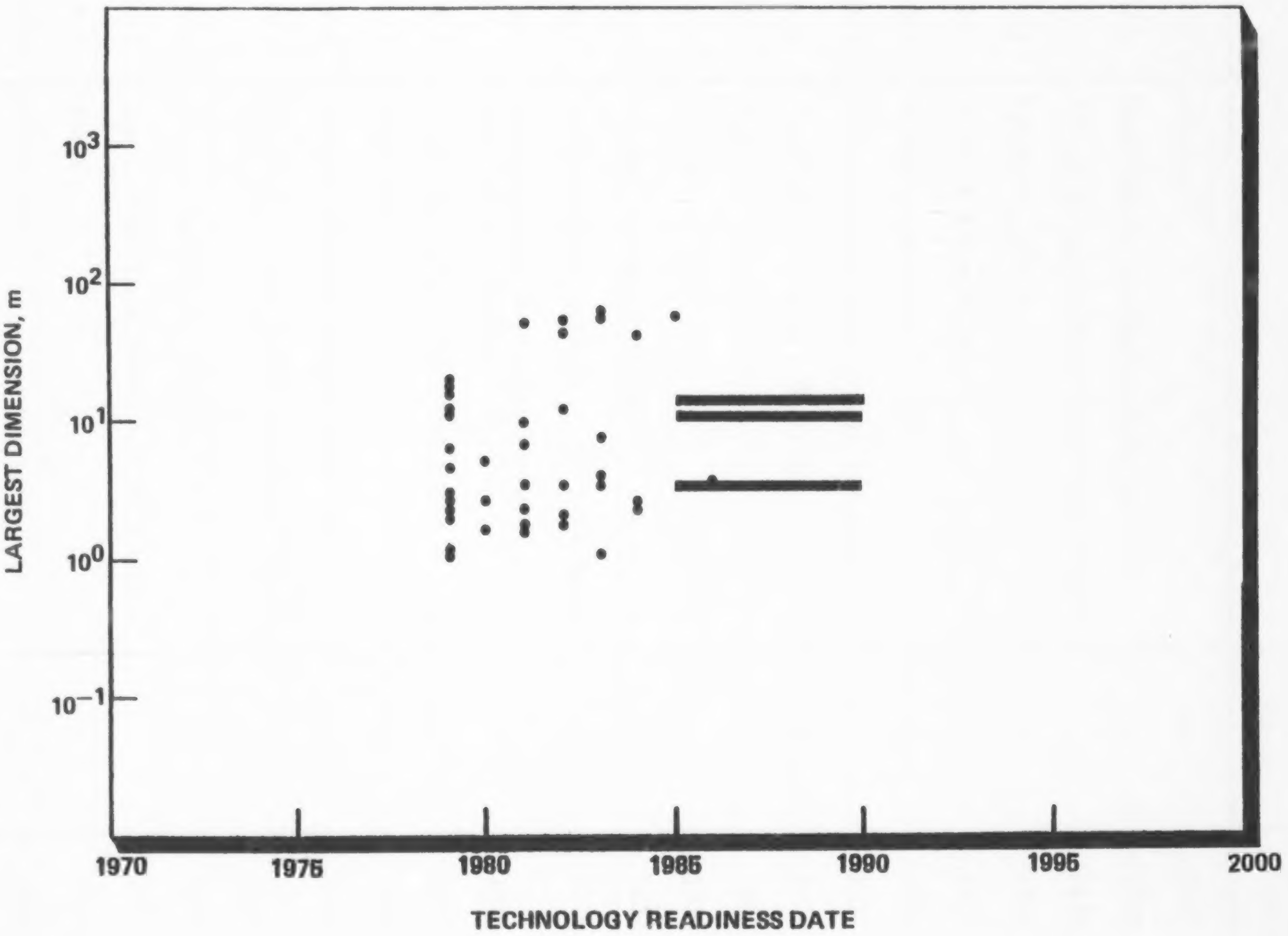
Physical Size (m)

No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	6×6×6	1982
P-3	International Comet Mission	70×6×6	1982
A-8	Gravity Probe B (GP-B)	4.2×4.2 dia	1982
S-8	Solar Soft X-Ray Telescope	6×1.2 dia	1982
L-2	Space Sciences Platform	80×30×9	1982
R-4	Gravsat A	4×1 dia	1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program	22	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program	>4	1982
T-11	Teleoperator Retrieval System	3.3×3.2×3.4	1982
U-7	Science & Applications Space Platform	83.5×13.1×9	1982
A-9	Advanced X-Ray Astrophysics Facility	11.5×3.1 dia	1983
A-10	X-Ray Timing Explorer	2×2×4	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration	80×30	1983
T-10	Orbital Transfer Vehicle	6.5 dia	1983
U-8	25-kW Power System	83.5×13.1 9	1983
U-9	Materials Experimentation Carrier	6×4.6 dia	1983
S-9	Subsatellite Facility	1.0×1.5 dia	1983

STRUCTURES

Physical Size (m)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	70×5×5	1984
P-5	Mars Advanced Technology (Sample Return)	ND	1984
A-11	Starlab	5×1.5 dia	<1984
S-11	Solar Probe	4.4×3.8 dia	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	80×15×9	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	10-15 dia	1985-1990
A-17	Large Ambient Deployable IR Telescope	15×12	1985-1990
P-6	Uranus, Neptune, Pluto Program	ND	1986
S-13	Solar Cycle and Dynamics Mission	6×2 dia	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	ND	<1990
A-13	Cosmic Ray Observatory	15×5 dia	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	6×4 dia	<1990
A-15	Very Long Base-Line Radio Interferometer	30 dia	<1990
U-11	Large Power Module		1990



Structures: Physical Size

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LIFE

Flight Duration (yr)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	4-6	1979
A-1	High Energy Astronomy Observatory-C	1	1979
A-2	Infrared Astronomical Satellite (IRAS)	1	1979
A-3	Space Telescope	5	1979
S-1	Solar Maximum Mission	1	1979
S-2	Dynamics Explorer	2	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	7-30 days	1979
R-1	Magsat	4-8 mo	1979
R-2	Landsat D	3	1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	1	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)	7	1979
E-3	Solar Mesosphere Explorer (SME)	1	1979
E-5	NOAA A-G	2	1979
E-4	Earth Radiation Budget Satellite	~ 2	1979
C-1	Tracking & Data Relay Satellite System (TDRSS)	10	1979
C-2	Search and Rescue Mission	1-2	1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

LIFE

Flight Duration (yr)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle	7 days	1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	2	1979
U-2	Spacelab	7-30 days	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	1	1980
S-4	Solar Optical Telescope (SOT)	7-21 days	1980
S-5	Chemical Release Module Facility	180 days	1980
A-5	Extreme Ultraviolet Explorer	1	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	7-30 days	1981
A-7	Gamma Ray Observatory (GRO)	2	1981
S-6	Active Magnetospheric Particle Tracer Experiment	1	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	4	1981
E-6	National Oceanic Satellite System (NOSS)	3	1981
T-9	Solar Electric Propulsion	5	1981
U-4	Tethered Satellite System	1.5-6.5 days	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package	≤48 days	1981

LIFE

Flight Duration (yr)

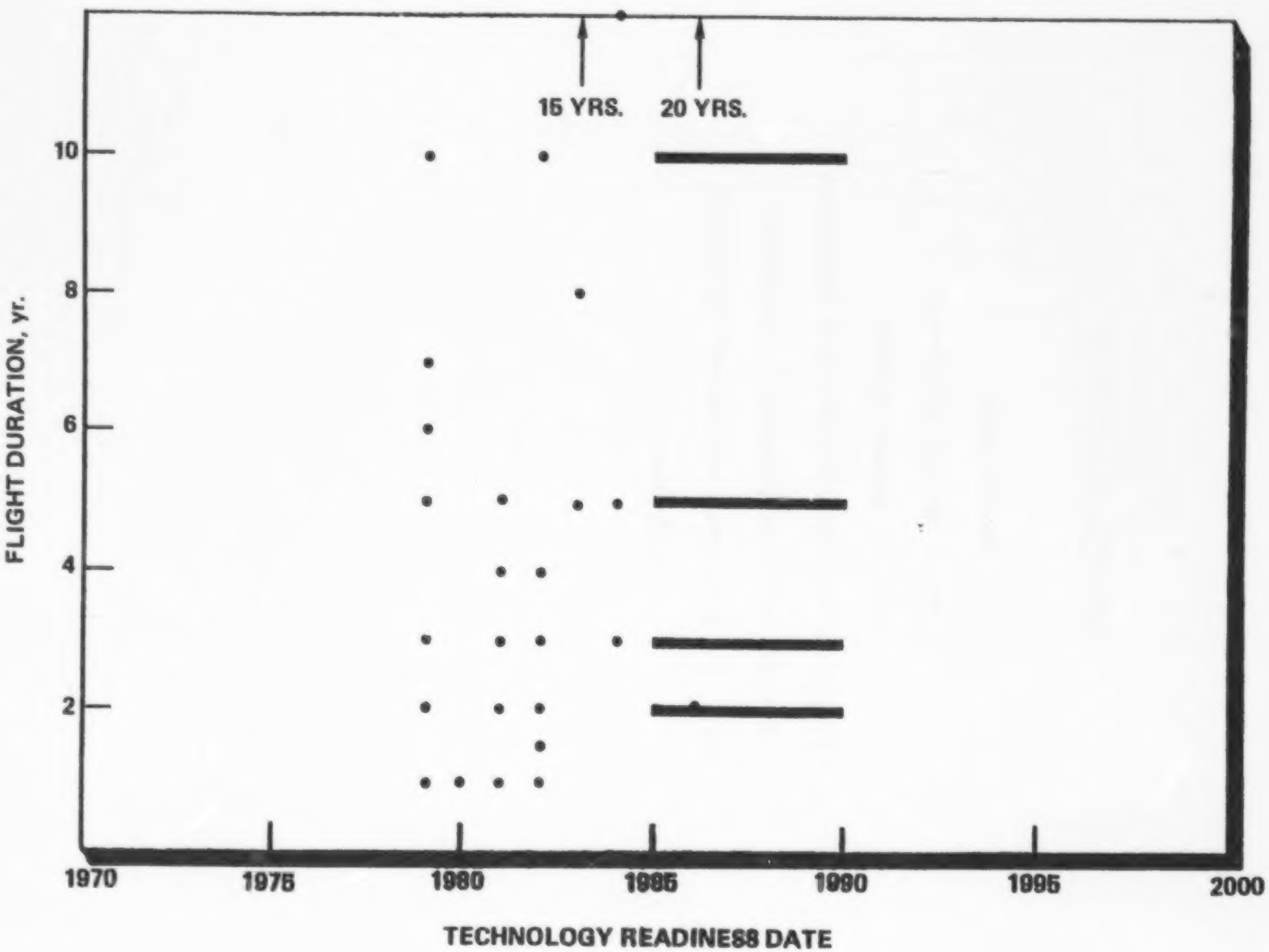
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	1	1982
P-3	International Comet Mission	4.0	1982
A-8	Gravity Probe B (GP-B)	1	1982
S-8	Solar Soft X-Ray Telescope	7-30 days	1982
L-2	Space Sciences Platform	10	1982
R-4	Gravsat A	0.75	1982
E-7	Upper Atmospheric Research Satellite (UARS)	1.5	1982
E-8	NOSS Research Program	3	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program	2	1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform	10	1982
A-9	Advanced X-Ray Astrophysics Facility	10-15	1983
A-10	X-Ray Timing Explorer	2-5	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration	8	1983
T-10	Orbital Transfer Vehicle	14-21 days	1983
U-8	25-kW Power System	5	1983
U-9	Materials Experimentation Carrier	30-90 days	1983
S-9	Subsatellite Facility	7-30 days	1983

LIFE

Flight Duration (yr)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	8-12	1984
P-5	Mars Advanced Technology (Sample Return)	3	1984
A-11	Starlab	7-30 days	<1984
S-11	Solar Probe	5	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	5	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	10	1985-1990
A-17	Large Ambient Deployable IR Telescope	5	1985-1990
P-6	Uranus, Neptune, Pluto Program	7-20	1986
S-13	Solar Cycle and Dynamics Mission	2	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	2	<1990
A-13	Cosmic Ray Observatory	2	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	2	<1990
A-15	Very Long Base-Line Radio Interferometer	3	<1990
U-11	Large Power Module		1990

TECHNOLOGY REQUIREMENTS SUMMARY



Life: Flight Duration

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INFORMATION SYSTEMS

Data Volume

On-Board Storage Capacity

Storage Device I/O Rate

Spacecraft Processors/Computers Memory Size

Spacecraft Processors/Computers Speed

Spacecraft Processors/Computers I/O Rates

Link Data Rate

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DATA PROCESSING

Data Volume (bits/day)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	10^{10}	1979
A-1	High Energy Astronomy Observatory-C	5×10^{8}	1979
A-2	Infrared Astronomical Satellite (IRAS)	5×10^{8}	1979
A-3	Space Telescope	10^{10}	1979
S-1	Solar Maximum Mission		1979
S-2	Dynamics Explorer		1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	ND	1979
R-1	Magsat	1.69×10^{8}	1979
R-2	Landsat D	4×10^{11}	1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	4.7×10^{8}	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	1.3×10^{7}	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite		1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

DATA PROCESSING

Data Volume (bits/day)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle		1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	NA	1979
U-2	Spacelab	3×10^9-3×10^{10}	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	ND	1980
S-4	Solar Optical Telescope (SOT)		1980
S-5	Chemical Release Module Facility		1980
A-5	Extreme Ultraviolet Explorer	10^8	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	ND	1981
A-7	Gamma Ray Observatory (GRO)	3×10^9	1981
S-6	Active Magnetospheric Particle Tracer Experiment		1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)		1981
E-6	National Oceanic Satellite System (NOSS)	2.7×10^{11}	1981
T-9	Solar Electric Propulsion		1981
U-4	Tethered Satellite System	TBD	1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package		1981

DATA PROCESSING

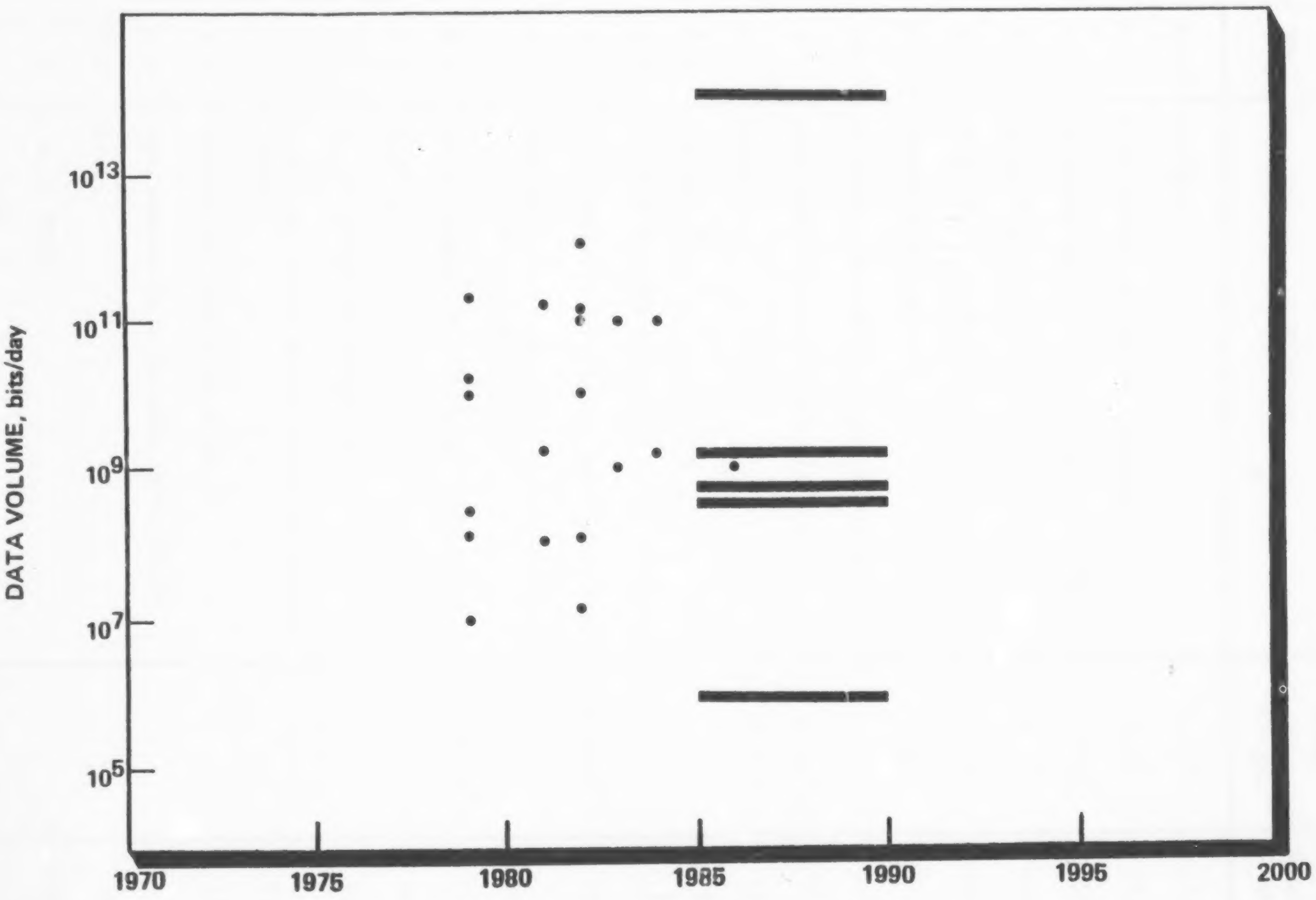
Data Volume (bits/day)

No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	2×10^{11}	1982
P-3	International Comet Mission	10^{10}	1982
A-8	Gravity Probe B (GP-B)	2.2×10^{7}	1982
S-8	Solar Soft X-Ray Telescope		1982
L-2	Space Sciences Platform	ND	1982
R-4	Gravsat A	10^{8}	1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program	10^{11}	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program		1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform	1×10^{12}	1982
A-9	Advanced X-Ray Astrophysics Facility	$10^{9}-10^{11}$	1983
A-10	X-Ray Timing Explorer	10^{9}	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System		1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility		1983

DATA PROCESSING

Data Volume (bits/day)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	3×10^9	1984
P-5	Mars Advanced Technology (Sample Return)	ND	1984
A-11	Starlab	10^9-10^{11}	<1984
S-11	Solar Probe		1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory		1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	10^5-10^6	1985-1990
A-17	Large Ambient Deployable IR Telescope	ND	1985-1990
P-6	Uranus, Neptune, Pluto Program	10^9	1986
S-13	Solar Cycle and Dynamics Mission		1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	2.5×10^9	<1990
A-13	Cosmic Ray Observatory	6×10^8	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	7×10^8	<1990
A-15	Very Long Base-Line Radio Interferometer	10^{11}-10^{14}	<1990
U-11	Large Power Module		1990



Data Processing: Data Volume

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DATA PROCESSING

On-Board Storage Capacity (bits)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	9×10^8	1979
A-1	High Energy Astronomy Observatory-C	3×10^8	1979
A-2	Infrared Astronomical Satellite (IRAS)	4.5×10^8	1979
A-3	Space Telescope	3×10^9	1979
S-1	Solar Maximum Mission	3×10^8	1979
S-2	Dynamics Explorer	4×10^8	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	4×10^{10}	1979
R-1	Magsat	9×10^7	1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	4.5×10^8	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)	4×10^6	1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite		1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

DATA PROCESSING

On-Board Storage Capacity (bits)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle		1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	3×10^8 2×10^4	1979
U-2	Spacelab	$3\times10^9-3\times10^{10}$	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	ND	1980
S-4	Solar Optical Telescope (SOT)	NA	1980
S-5	Chemical Release Module Facility	ND	1980
A-5	Extreme Ultraviolet Explorer	2×10^8	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)	NA	1981
A-7	Gamma Ray Observatory (GRO)	10^8-10^9	1981
S-6	Active Magnetospheric Particle Tracer Experiment	8.8×10^7	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	ND	1981
E-6	National Oceanic Satellite System (NOSS)	9×10^8	1981
T-9	Solar Electric Propulsion		1981
U-4	Tethered Satellite System		1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package		1981

DATA PROCESSING

On-Board Storage Capacity (bits)

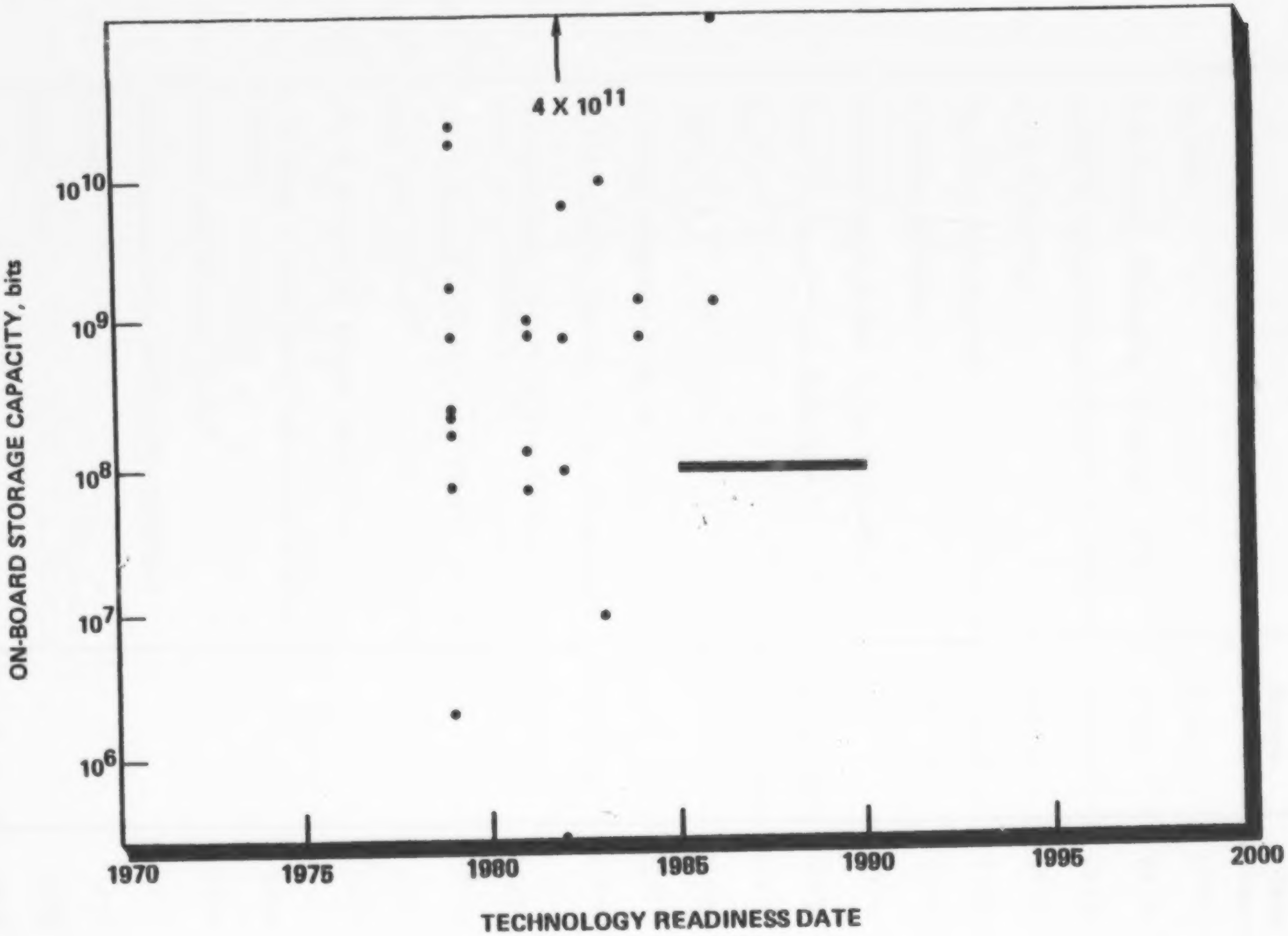
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	8×10^9	1982
P-3	International Comet Mission	9×10^8	1982
A-8	Gravity Probe B (GP-B)	5×10^5	1982
S-8	Solar Soft X-Ray Telescope	ND	1982
L-2	Space Sciences Platform	ND	1982
R-4	Gravsat A	10^8	1982
E-7	Upper Atmospheric Research Satellite (UARS)	10^8	1982
E-8	NOSS Research Program	4×10^{11} (3 tape recorders) 4×10^9 (2 tape recorders)	1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program		1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform		1982
A-9	Advanced X-Ray Astrophysics Facility	10^{10}	1983
A-10	X-Ray Timing Explorer	10^7	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System		1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility	10^{10}	1983

DATA PROCESSING

On-Board Storage Capacity (bits)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	9×10^8	1984
P-5	Mars Advanced Technology (Sample Return)	ND	1984
A-11	Starlab	ND	<1984
S-11	Solar Probe	2×10^9	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	ND	1985
R-7	Magnetic Field Survey B	10^8	1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	ND	1985-1990
A-17	Large Ambient Deployable IR Telescope	ND	1985-1990
P-6	Uranus, Neptune, Pluto Program	10^9-10^{11}	1986
S-13	Solar Cycle and Dynamics Mission	2×10^9	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	10^8	<1990
A-13	Cosmic Ray Observatory	ND	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	ND	<1990
A-15	Very Long Base-Line Radio Interferometer	ND	<1990
U-11	Large Power Module		1990

TECHNOLOGY REQUIREMENTS SUMMARY



Data Processing: On-Board Storage Capacity

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DATA PROCESSING

Storage Device I/O Rates (kbps)

No.	Mission	Value or Range	Technology Readiness Date
P-1	Galileo	8-400	1979
A-1	High Energy Astronomy Observatory-C	6/128	1979
A-2	Infrared Astronomical Satellite (IRAS)	8/1048	1979
A-3	Space Telescope	4-1024	1979
S-1	Solar Maximum Mission	16/1024	1979
S-2	Dynamics Explorer	16/128	1979
S-3	International Solar Polar Mission		1979
L-1	Spacelab Biological Experiments	64/16,000	1979
R-1	Magsat	$2/3.2\times10^2$	1979
R-2	Landsat D		1979
R-3	Crustal Dynamics Program		1979
E-1	Stratospheric Aerosol & Gas Experiment	5.44/328	1979
E-2	Geostationary Orbit Environment Satellite-3 (GOES/D,E,F)		1979
E-3	Solar Mesosphere Explorer (SME)		1979
E-5	NOAA A-G		1979
E-4	Earth Radiation Budget Satellite		1979
C-1	Tracking & Data Relay Satellite System (TDRSS)		1979
C-2	Search and Rescue Mission		1979
C-3	Application Data Service Development		1979
T-1	Scout		1979
T-2	Delta 3914		1979
T-3	Atlas-F		1979

DATA PROCESSING

Storage Device I/O Rates (kbps)

No.	Mission	Value or Range	Technology Readiness Date
T-4	Atlas/Centaur		1979
T-5	Space Shuttle		1979
T-6	Spinning Solid Upper Stage		1979
T-8	Inertial Upper Stage (IUS)		1979
T-7	Multimission Modular Spacecraft	512(STDN) 1024(TDRSS)	1979
U-2	Spacelab	10×10^3-30×10^3	1979
U-3	Extraterrestrial Materials Processing		1979
U-1	National Materials Laboratory		1979
A-4	Cosmic Background Explorer (COBE)	4-640	1980
S-4	Solar Optical Telescope (SOT)	NA	1980
S-5	Chemical Release Module Facility	ND	1980
A-5	Extreme Ultraviolet Explorer	3.2	1981
A-6	Shuttle Infrared Telescope Facility (SIRTF)		1981
A-7	Gamma Ray Observatory (GRO)	32	1981
S-6	Active Magnetospheric Particle Tracer Experiment	1-120	1981
S-7	Origin of Plasma in the Earth's Neighborhood (OPEN)	4-100	1981
E-6	National Oceanic Satellite System (NOSS)	32-50 low rate 1.5-10×10^3 high rate	1981
T-9	Solar Electric Propulsion		1981
U-4	Tethered Satellite System		1981
U-5	Large Space Structures Technology and Development Program		1981
U-6	Power Extension Package		1981

DATA PROCESSING

Storage Device I/O Rates (kbps)

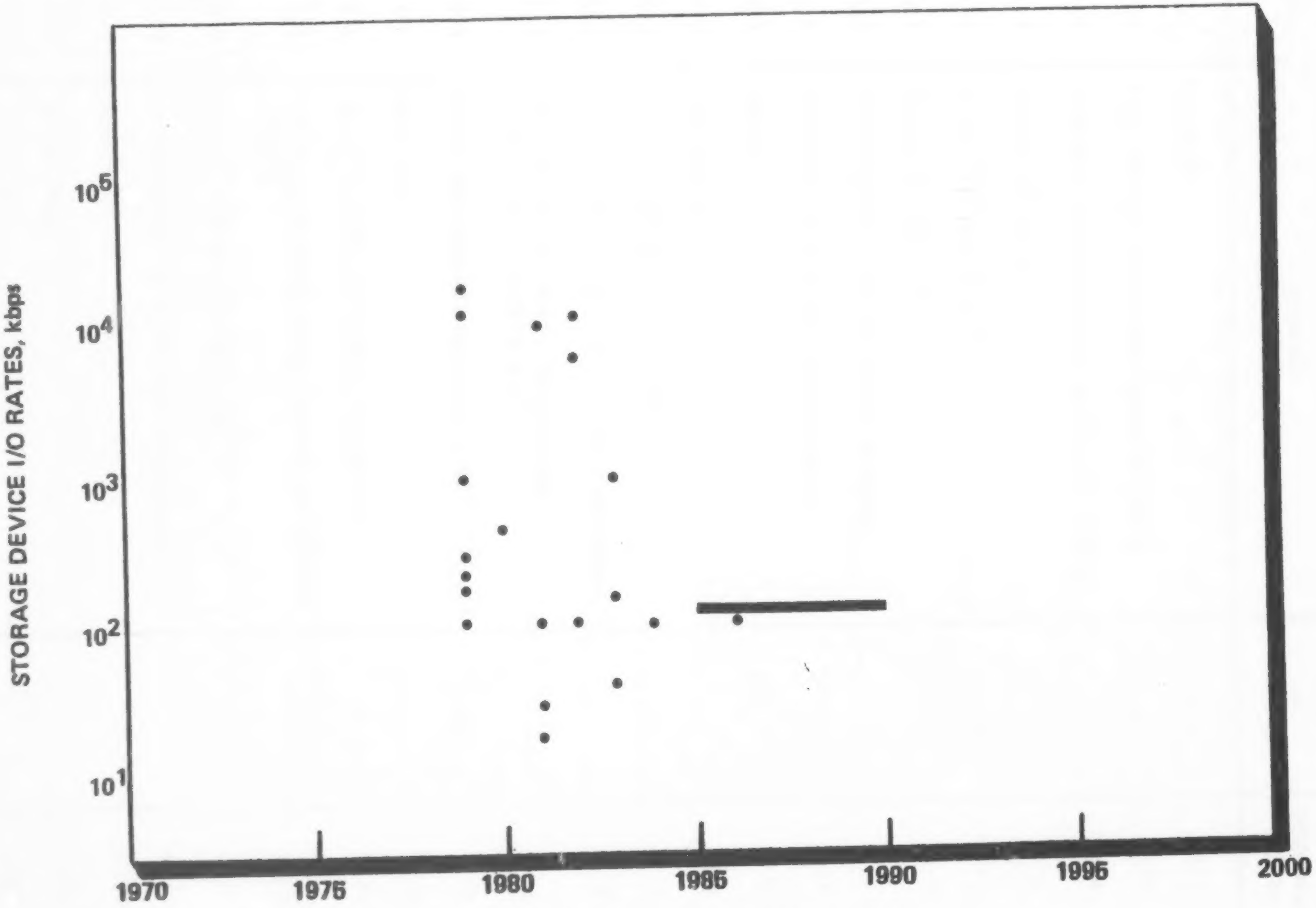
No.	Mission	Value or Range	Technology Readiness Date
P-2	Venus Orbiting Imaging Radar	8192	1982
P-3	International Comet Mission	120	1982
A-8	Gravity Probe B (GP-B)	<1	1982
S-8	Solar Soft X-Ray Telescope	ND	1982
L-2	Space Sciences Platform	ND	1982
R-4	Gravsat A		1982
E-7	Upper Atmospheric Research Satellite (UARS)		1982
E-8	NOSS Research Program		1982
C-4	30/20 GHz Antenna Wideband Communications Satellite Program		1982
T-11	Teleoperator Retrieval System	TBD	1982
U-7	Science & Applications Space Platform	$0.1\text{-}1.4\times10^4$	1982
A-9	Advanced X-Ray Astrophysics Facility	1000	1983
A-10	X-Ray Timing Explorer	64	1983
S-10	Plasma Turbulence Experiment		1983
R-5	Operational Earth Resources System		1983
E-9	Ocean Circulation Mission--Topography Experiment (TOPEX)		1983
C-5	Geostationary Platform Demonstration		1983
T-10	Orbital Transfer Vehicle		1983
U-8	25-kW Power System	4.0	1983
U-9	Materials Experimentation Carrier		1983
S-9	Subsatellite Facility	256	1983

DATA PROCESSING

Storage Device I/O Rates (kbps)

No.	Mission	Value or Range	Technology Readiness Date
P-4	Saturn Orbiter Dual Probe	115	1984
P-5	Mars Advanced Technology (Sample Return)	ND	1984
A-11	Starlab	ND	<1984
S-11	Solar Probe	100	1984
R-6	Advanced Thermal Mapping Applications Satellite		1984
S-12	Solar Terrestrial Observatory	ND	1985
R-7	Magnetic Field Survey B		1985
R-8	Soil Moisture Research and Assessment		Mid 1980s
E-10	Operational Meteorology Satellite System		Mid 1980s
E-11	Ocean Research (SAR)		1985
A-16	Orbiting Submillimeter Telescope	ND	1985-1990
A-17	Large Ambient Deployable IR Telescope	ND	1985-1990
P-6	Uranus, Neptune, Pluto Program	120	1986
S-13	Solar Cycle and Dynamics Mission	ND	1986
T-12	Manned GEO Sortie		1986
U-10	Materials Experiment Carrier II		1986
A-12	X-Ray Observatory	20-200	<1990
A-13	Cosmic Ray Observatory	ND	<1990
A-14	Large Area Modular Array of Reflectors (LAMAR)	ND	<1990
A-15	Very Long Base-Line Radio Interferometer	ND	<1990
U-11	Large Power Module		1990

TECHNOLOGY REQUIREMENTS SUMMARY



Data Processing: Storage Device I/O Rate

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NASA

SPACE SYSTEMS TECHNOLOGY MODEL

VOLUME II

Space Technology Trends and Forecasts

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Office of Aeronautics and Space Technology
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NAS 1.2:

General Introduction
Introduction to Volume II
1. Power and Electric Propulsion
  Photovoltaic Energy Conversion
  Space Energy Conversion and Storage
  Thermal-to-Electric Energy Conversion
  Power Systems
  Electric Propulsion
2. Chemical Propulsion
3. Materials and Structures
4. Information Systems
  Sensors
  Data Processing
  Communications
5. Navigation, Guidance & Control
6. Automated Operations

NASA

Space Systems Technology Model

VOLUME II: SPACE TECHNOLOGY TRENDS AND FORECASTS

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Washington, D.C. 20546

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GENERAL INTRODUCTION

This document is the second issue of the Space Systems Technology Model. This issue received NASA-wide inputs and coordination; the first issue was constructed solely for OAST internal usage. This Model will be revised and published on an annual basis. It contains NASA system and program requirements, technology trends, and forecasts for space technology. The Model provides a base of information for guiding technology development for future systems and programs. It also displays the expected availability of technology improvements to enable and/or enhance future missions.

PURPOSE OF THE MODEL

The purpose of the NASA Space Systems Technology Model is to serve as a reference for: planning technology programs and options; identifying technologies required for planned and potential future missions; assessing ongoing technology programs; and providing a technology reference source for mission planning. Ascertaining technology requirements for planned and future missions assures that the focus of technology programs is coupled to the overall goals and missions of NASA.

The system technology needs and requirements presented in the Technology Model do not constitute official agency plans, but may be used in their developments. The Model is a broader menu of candidate and opportunity systems and programs for the future than current funding expectations will allow.

GENERAL DESCRIPTION

The three volumes of the Model treat systems, programs, and technology from the present to reasonable limits of projection.

Volume I contains those systems and programs which the NASA program offices endorse as being within their ten-year planning horizon.

Volume II contains trends and forecasts of space technology.

Volume III provides information about innovative systems, programs, and technology. Part A presents systems and programs which are validated by program offices, but which are either beyond the ten-year planning period or are still deemed speculative. Part B systems and programs derive from sources other than the program offices and, as such, are considered more speculative than Part A missions. Part C presents emerging technologies with little-to-no historical trend, and provides best-possible forecasts of their potential.

The information in the Model has been assembled from a variety of written and oral sources. Validated information contained in the Model has been identified by tracable, formal reference to the responsible NASA Headquarters office. The emphasis is on quantitative descriptions where possible.

The elements presented in the Model include:

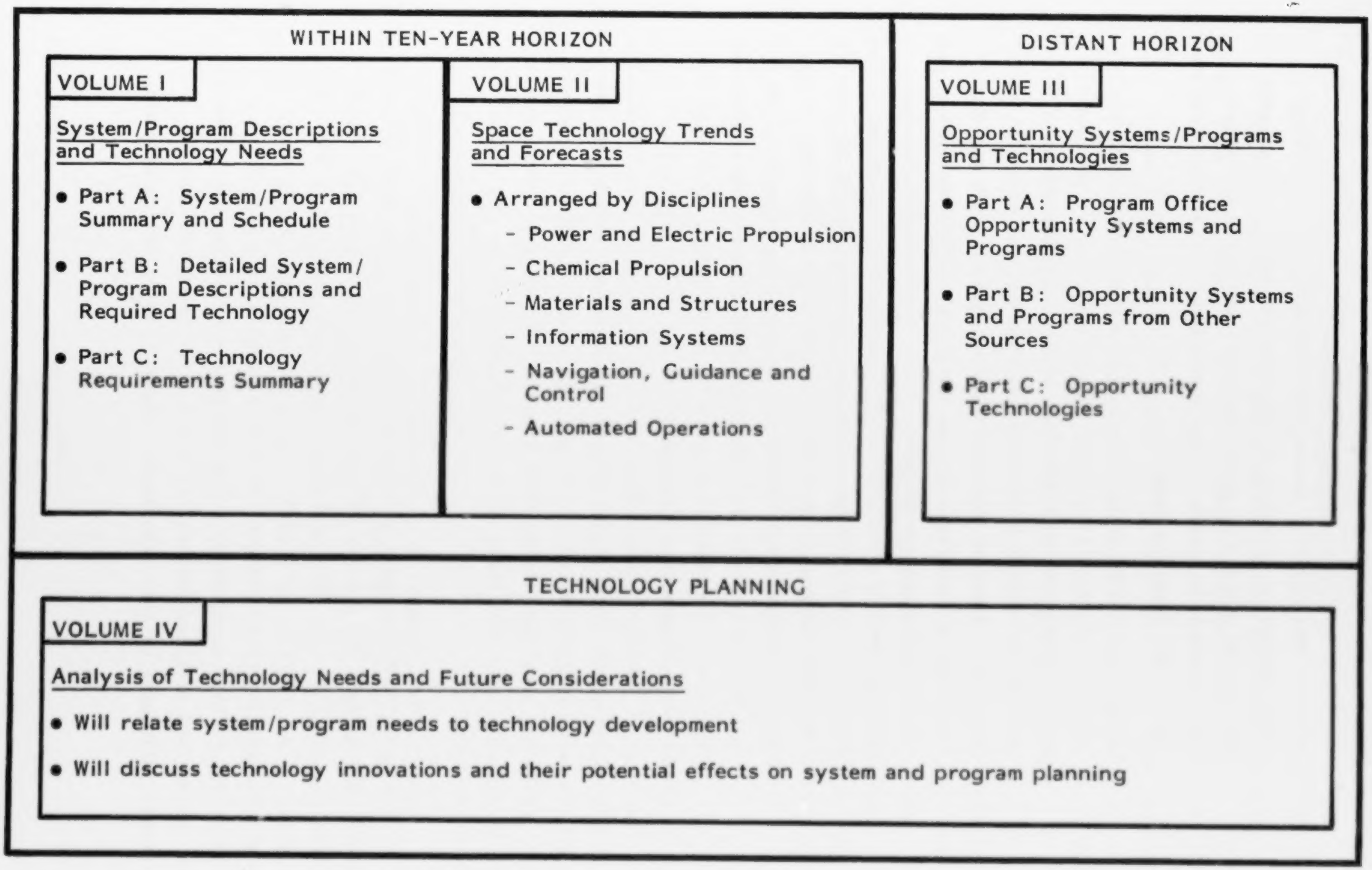
1. Mission Systems. An assemblage of hardware and software, ground- or space-based, whose functions are integrated to achieve a program-level objective. Examples are Venus Orbiting Imaging Radar, Space Shuttle, and the National Oceanic Satellite System.

2. Mission Instruments. Scientific equipment for performing experimental or operational measurements which are intended for use in space. Examples are Electromagnetic Containerless Processing System, Solar Backscatter Ultraviolet Spectrometer, and Thematic Mapper.

3. Programs. Funded activities that are approved or are prospective discrete elements of the space budget. Included are: flight programs which use mission and instrument systems to conduct experiments and demonstrate capabilities in space. Examples are the Space Science Platform and the Large Space Structures System Technology and Development Plan. Investigatory programs which are nonflight specific aggregations of activities, often analytic in nature but which may contain flight elements. Examples are 30/20 GHz Wideband Communications satellite program and the National Materials Laboratory. Functional service programs which provide users with space-derived information, capabilities, or methods. An example is the Application Data Service Development program.

In summary, the items presented are the implements which NASA has or envisions to achieve the perceived goals of the civil space program. These goals are expressed in the NASA Five-Year Planning Document, published annually, and this Model serves as a supplement to the current "Five-Year Plan."

The content of the three volumes and their parts has been selected to maintain a clear distinction between different levels of planning information (see Fig. 1). The information in Volume I is for definitive programs, i.e., systems and programs which are approved, planned, or candidates for initiation within the next ten years (see Fig. 2 for definition of these categories). The information contained in Volume III, for systems and programs expected to start after ten years, can be strongly influenced by new technology. Figure 3 shows the relationship



WITHIN TEN-YEAR HORIZON

VOLUME I

System/Program Descriptions and Technology Needs

- Part A: System/Program Summary and Schedule
- Part B: Detailed System/Program Descriptions and Required Technology
- Part C: Technology Requirements Summary

VOLUME II

Space Technology Trends and Forecasts

- Arranged by Disciplines
  - Power and Electric Propulsion
  - Chemical Propulsion
  - Materials and Structures
  - Information Systems
  - Navigation, Guidance and Control
  - Automated Operations

DISTANT HORIZON

VOLUME III

Opportunity Systems/Programs and Technologies

- Part A: Program Office Opportunity Systems and Programs
- Part B: Opportunity Systems and Programs from Other Sources
- Part C: Opportunity Technologies

TECHNOLOGY PLANNING

VOLUME IV

Analysis of Technology Needs and Future Considerations

- Will relate system/program needs to technology development
- Will discuss technology innovations and their potential effects on system and program planning

Figure 1. NASA Space Systems Technology Model

VOLUME I

APPROVED - A

MISSIONS WHICH HAVE BEEN FUNDED AND AUTHORIZED FOR IMPLEMENTATION.

PLANNED - P

MISSIONS DESIGNATED BY THE PROGRAM OFFICES AS POSSIBLE NEW STARTS WITHIN THE NEXT FIVE YEARS.

CANDIDATE - C

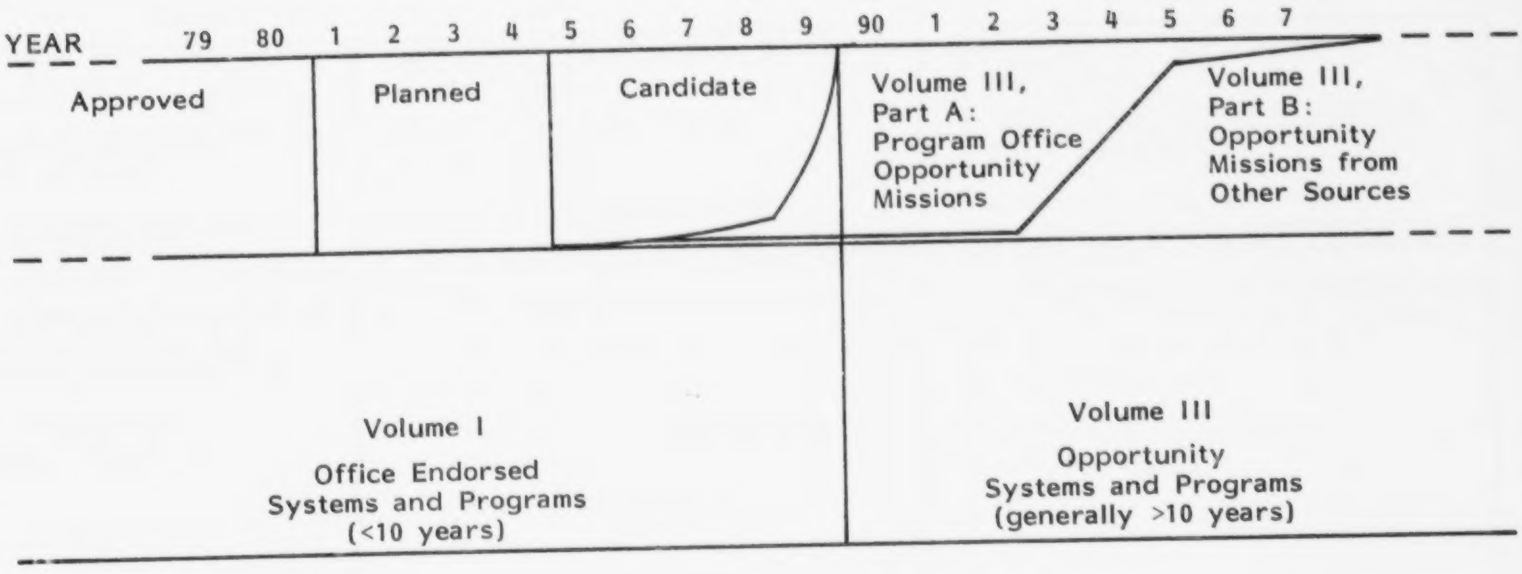
MISSIONS CONSIDERED FOR POSSIBLE INITIATION WITHIN TEN YEARS, BUT CURRENTLY NOT PLANNED AS A NEW START WITHIN THE NEXT FIVE YEARS.

VOLUME III

OPPORTUNITY - O

POTENTIAL MISSIONS FOR START BEYOND TEN YEARS AND/OR THOSE MISSIONS OF A SPECULATIVE NATURE. SUCH MISSIONS PROVIDE OPPORTUNITIES FOR TECHNOLOGY DEVELOPMENT TO SHAPE SYSTEM DESIGNS.

Figure 2. Categories of Systems and Programs


YEAR
79
80
1
2
3
4
5
6
7
8
9
90
1
2
3
4
5
6
7
Approved
Planned
Candidate
Volume III,
Part A:
Program Office
Opportunity
Missions
Volume III,
Part B:
Opportunity
Missions from
Other Sources
Volume I
Office Endorsed
Systems and Programs
(<10 years)
Volume III
Opportunity
Systems and Programs
(generally >10 years)

NOTE: Systems/programs are included in Model if flight or start is 1979 or later.

Figure 3. Model Presentation of NASA Systems and Programs

between the categories, time, and the volumes of this Model. The technology trends and forecast information has been similarly separated into two volumes. Volume II presents data for ongoing and forecastable technology developments. Volume III, Part C presents data on opportunity technologies which have no current credible system or program applications or which cannot be forecasted now.

VOLUME I

Volume I, System/Program Descriptions and Technology Needs, contains details on systems and programs endorsed by the responsible program offices for a start in the next ten years. Identification of the systems and programs and their relative time phasing was obtained from the program offices at NASA Headquarters by means of several iterated reviews over the last six months. Technical characteristics of the systems and programs were compiled to the extent available and subjected to review and validation by the responsible program offices.

The systems and programs are grouped in categories corresponding to basic NASA program areas: Planetary, Astrophysics, Solar Terrestrial, Life Sciences, Resource Observation, Global Environment, Communications, Space Transportation, Utilization of the Space Environment, and Technology Development (OAST instrument systems). They are sequenced by funding and/or development status (Fig. 2). Funded, ongoing systems and programs are designated Approved. Those identifed as possible new starts within the next five years are designated as Planned. Systems and programs identified as new starts within the present five-year plan period but considered for possible initiation within ten years are designated Candidate. Those potentially starting after ten years and/or those of a speculative nature are designated Opportunity; they are presented in Volume III.

Volume I is arranged in three parts:

Part A: System/Program Summary and Schedule

- This is a chronological list of systems and programs by program area (Planetary, Astrophysics, etc.). The list includes system/program name, status, source, start data for major effort, launch data if applicable, and primary contact for information.
- At the end of Part A, the start dates are displayed graphically by program area.

Part B: Detailed System/Program Descriptions and Required Technology

A section for each mission system or program presents technical details.

- The first page presents general information: an illustration; basic features; and narrative on objective, description, technology needs, references, and contacts.
- Following pages present technical characteristics to the extent that they are now known or relevant. A technical characteristic is generally presented as a nominal value, the degree of confidence in the value, and the state of technology readiness. Comments are provided to explain particular conditions.
- Instrument systems are presented in a format which contains name, status, carrier, physical and general properties, principal purpose and features, principal physical property measured, associated ranges and resolutions, comments, sources, and contacts. For the science programs (Planetary, Astrophysics, Solar Terrestrial, and Life Sciences) the instrument systems are not presented separately, but are grouped on a sheet with the related mission system.

Part C: Technology Requirements Summary

Values of particular technical characteristics are tabulated for all mission systems. The data are further presented versus time. Analysis of the plotted data should reveal trends in technology demanded by the aggregate of NASA mission systems and programs envisioned for the next ten years. In Volume III, Part A, the characteristics of mission systems and programs beyond ten years are added to these plots.

VOLUME II

Volume II, Space Technology Trends and Forecasts, presents data characterizing space technology developments. The present and projected status of space technology is arranged by discipline: power and electric propulsion; chemical propulsion; materials and structures, information systems; navigation, guidance and control; and automated operations. Past technology trends, state of the art, and a ten-year or more forecast of capabilities are included.

These forecasts were obtained from NASA technology development managers at Headquarters and the Centers. The technology development managers were asked to identify figures of merit for technology discipline and forecast their growth. The resulting set of forecasts in Volume II can be related in many cases to Volumes I and III system and program characteristics.

VOLUME III

Volume III, Opportunity Systems/Programs and Technologies, is divided into three parts:

- Part A: Program Office Opportunity Systems and Programs, presents technical details on systems and programs which the offices endorse but which are speculative or beyond ten years. The format is identical to Volume I, Parts B and C. These missions are called "opportunity" because there is ample time for vigorous technology development to greatly impact their form and feasibility.
- Part B: Opportunity Systems and Programs from Other Sources, presents a selection of systems and programs which cannot now be advocated by the NASA program offices for various reasons; they are too distant, too speculative in feasibility, pertinence, or utility; or too controversial.
- Part C: Opportunity Technologies, presents information on emerging technologies. Opportunity technology often provides revolutionary advances which may enable otherwise unachievable mission systems. The format is a one-page description of contacts, character, relation to mission and instrument systems and other technologies, status descriptors, and coarse forecasts.

VOLUME IV

(to be supplied at a later date)

Volume IV, Analysis of Technology Needs and Future Considerations, was to relate system and program needs to technology development and discuss technology innovations and their potential effects on mission and program planning. As of the date of this issue, Volume IV has not been produced. NASA Headquarters, supported by the Centers, is preparing technology development plans which would form the essence of this volume. Drafts of Volumes I, II, and III of the Model served as the primary basis for preparing these plans. Further evolution will lead to a presentation of technology plans in a formal Volume IV.

MODEL USE AND MAINTENANCE

The NASA Space Systems Technology Model is an outcome of the space technology program planning and implementation process. The Model is intended to be a companion to the NASA Five-Year Planning Document and will be updated annually. It is believed that the Model will improve steadily through subsequent iterations.

Requests for additional copies of the Model should be addressed to Stan Sadin, Code RS-5, NASA Headquarters, Washington, DC 20546. Comments and suggestions for additional information to be included in future updates should be sent to the same address.

ACKNOWLEDGMENTS

This Model is the product of support from many organizations and individuals. An acknowledgment of the contributors appears at the end of this volume.

William J Cuneo Jr

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OAST/RS

S R Sadin

Stan R. Sadin
Deputy Director,
Program Development
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INTRODUCTION TO VOLUME II

Volume II, Space Technology Trends and Forecasts, presents trends and forecasts for a number of critical, quantitative parameters of figures of merit, which may be used to characterize technological capabilities in the major discipline areas of space technology. The trends are based on historical data, and the forecasts represent the considered concensus opinions of knowledgeable experts in NASA Centers and Headquarters who are active contributors in their respective fields.

The major discipline areas included in this volume are:

1 Power and Electric Propulsion
  1.1 Photovoltaic Energy Conversion
  1.2 Space Energy Conversion and Storage
  1.3 Space Power Reactor/Conversion Technology
  1.4 Power Systems Management and Distribution
  1.5 Electric Propulsion

2 Chemical Propulsion

3 Materials and Structures

4 Information Systems
  4.1 Sensors
  4.2 Data Processing
  4.3 Communications

5 Navigation, Guidance and Control

6 Automated Operations

For the most part, the trends and forecasts presented here consist of a graphical display for each relevant figure of merit, accompanied by a descriptive narrative which explains the rationale and assumptions behind the forecast. This material is generally preceded by introductory remarks, an explanation of the figure of merit chosen to characterize the technology, a summary of the present state of that technology, and where appropriate, explanations of the goals and objectives of NASA and other technology development programs.

The graphical displays were prepared against the following guidelines and definitions.

- They should show a development trend with a discrete value for present capability.
- Where deemed feasible, they show a "most probable" forecast line (assuming sustained current level-of-effort funding, except where otherwise noted by the contributor), bracketed by a range of optimistic and pessimistic views of future progress, as defined by the contributor.
- Where used, "technology readiness date" is defined as the year the technology would be accepted for use in Phase B planning. Nominally, the technology would be expected to be demonstrated to the required capability level five years before the anticipated launch date of the mission.

The narrative material is intended to substantiate the forecasts by citing ongoing development programs, proposed enhancements, goals, objectives, and schedules for NASA research and technology development, other agencies, and the private sector. Attempts have been made to present and discuss discrete forecasts for the year 1990 for each figure of merit. Technology readiness levels, as defined on the opposite page, are used to define the degree of development being forecast. When a technology readiness level is not identified, "Level 7" technology readiness is to be understood.

Material was solicited from the expert contributors against the aforementioned guidelines. However, little attempt was made during the editorial process to confine the authors to this particular framework. Thus, there may be individual departures from this format, depending on the nature of the materials being discussed and the individual contributor's presentation styles.

The material presented herein has been subjected to review by the contributor's professional peers. However, the speculative nature of underlying assumptions behind and inherent uncertainty of such forecasts should be kept in mind by the users of this document.

TECHNOLOGY READINESS LEVELS

LEVEL 1	BASIC PRINCIPLES OBSERVED AND REPORTED
LEVEL 2	CONCEPTUAL DESIGN FORMULATED
LEVEL 3	CONCEPTUAL DESIGN TESTED ANALYTICALLY OR EXPERIMENTALLY
LEVEL 4	CRITICAL FUNCTION/CHARACTERISTIC DEMONSTRATION
LEVEL 5	COMPONENT/BREADBOARD TESTED IN RELEVANT ENVIRONMENT
LEVEL 6	PROTOTYPE/ENGINEERING MODEL TESTED IN RELEVANT ENVIRONMENT
LEVEL 7	ENGINEERING MODEL TESTED IN SPACE

ACKNOWLEDGMENTS

The following NASA Headquarters personnel coordinated the preparation of the technology trends and forecasts in their respective discipline areas:

1.	Power and Electric Propulsion	J. P. Mullin
2.	Chemical Propulsion	F. W. Stephenson
3.	Materials and Structures	W. A. Brainard
4.	Information Systems	
	Sensors	B. Rubin
	Data Processing and Communications	L. B. Holcomb
5.	Navigation, Guidance and Control	W. B. Gevarter
6.	Automated Operations	W. B. Gevarter

The technical experts at NASA's field centers who furnished the actual trends and forecasts presented in this volume are too numerous to delineate here, but by-line credit has been given when possible.

R. W. Riebling served as overall coordinator and editor of this volume.

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ACRONYMS

AMO	air mass zero (solar cells)
AMS	advanced mapping spectrometer
ASAR	advanced synthetic aperture radar
ASPS	annular suspension and pointing system
ATS	applications technology satellite
AU	astronomical unit; the mean earth-sun distance
BAC	Boeing Aircraft Company
BOL	beginning of life
CASTS	composites for advanced space transportation systems
CCD	charged-coupled device
CCIRID	charged-coupled infrared imaging device
CTD	charged-transfer device
CVD	chemical vapor deposition
CW	continuous wave
DDS	distributed data system
DIAL	differential absorption lidar
DoD	Department of Defense
DOD	depth of discharge (batteries)
DSN	deep space network
DSRV	deep submergence rescue vehicle
EOL	end of life
FDM	frequency division multiplexing
FET	field effect transistor
FOV	field of view
GE	General Electric

ACRONYMS (Cont.)

GEO	geosynchronous earth orbit
GLL	Galileo mission
GSFC	Goddard Space Flight Center
IF	intermediate frequency
IFOV	instantaneous field of view
IMC	image motion compensation
IMPATT	impact avalanche and transit time (diode)
IR	infrared
IRAS	infrared astronomical satellite
ISPM	international solar polar mission
IUS	inertial upper stage
LAMMR	large antenna multifrequency microwave radiometer
LEO	low earth orbit
LHS	laser heterodyne spectrometer
LO	local oscillator
LNA	low noise amplifier
LSI	large scale integration
LSST	large space systems technology
MDP	master data processing
MIC	microwave integrated circuit
MIS	metal insulator semiconductor
MNOS	metal nitride oxide semiconductor
MOPS	millions of operations per second
MOSFET	metal oxide-silicon field-effect transistor
MPP	massively parallel processor

ACRONYMS (Cont.)

MSFC	Marshall Space Flight Center
NEEDS	NASA end-to-end data system
NEP	nuclear electric propulsion
NIMS	near-infrared mapping spectrometer
NOAA	National Oceanic and Atmospheric Administration
NOSS	National Oceanic Satellite System
OAST	Office of Aeronautics and Space Technology
OEX	orbiter experiment
OSTA	Office of Space and Terrestrial Applications
OTV	orbit transfer vehicle
OSTDS	Office of Space Tracking and Data Systems
PC	photoconducting
PPTS	precision pointing and tracking system
R&D	research and development
RSI	reusable surface insulation
RT&E	research, technology and engineering
RTG	radioisotope thermoelectric generator
RTOP	research and technology operating plan
SAR	synthetic aperture radar
SEP	solar electric propulsion
SIR-A	Shuttle imaging radar "A"
SMMR	scanning multichannel microwave radiometer
SMMW	submillimeter wave
SPE	solid polymer electrolyte (fuel cells)
SRT	supporting research and technology

ACRONYMS (Cont.)

SSME	space shuttle main engine
STS	space transportation system
TDI	time delay and integration
TDM	time division multiplexing
TPS	thermal protection system
TWT	traveling wave tube
UV	ultraviolet
VLSI	very large scale integration
VOIR	Venus Orbiter Imaging Radar

1 POWER AND ELECTRIC PROPULSION

1.1 PHOTOVOLTAIC ENERGY CONVERSION

Solar Array (W. A. Hasbach, Jet Propulsion Laboratory)

Solar array technology is being advanced in several areas. OAST R&T development programs are directed at increasing the level of electric power available while reducing the specific costs. The technologies to accomplish these goals are in the areas of: reduced specific mass and volume; increased efficiency of solar conversion components; and increased operating life of cells and arrays. Weight reduction for deployable structures is under development using composite materials and flexible array blankets.

Although silicon cell technology may be approaching the practical limits of efficiency ($\sim$18%), major efforts in silicon research are being directed towards ultrathin ($\leq$50 μm) cells possessing efficiencies nearly as great as devices of conventional thickness ($\geq$200 μm). Ultrathin silicon cell research should offer opportunity for greatly improved resistance to radiation. Another approach that could provide substantial improvement in effective radiation resistance involves the development of techniques to rejuvenate cells by in-situ annealing. Present power output of silicon cells degrades by 25% from beginning of life (BOL) levels in 7 to 10 years for spacecraft in high earth orbits (GEO). Restoration of close to original capability would reduce size and weight penalties for long-duration missions.

Gallium arsenide cell technology is being developed to utilize its efficiency and reduced susceptibility to radiation damage. Ultrathin ($\leq$50 μm) approaches to gallium arsenide such as chemical vapor deposition (CVD) technology would provide very high efficiency ($\sim$20% air mass zero, AMO) and excellent radiation resistance ($\sim$10% reduction in BOL after 10 years). Development of multiple bandgap technology cell designs permitting 30% conversion efficiency would offer significant improvement in array power output and/or mass reduction. These developments coupled with encapsulation technology, which offers an economical, low-mass alternative to cover glasses, would improve array performance dramatically.

OAST is currently funding programs in thin cell technology, encapsulation techniques, GaAs cell development, multiple bandgap technology, radiation-resistant cells, and blanket and array designs that minimize structure weight and subsystem costs. Breakthroughs in these development programs, particularly in the multiple bandgap cells, would significantly enhance the expected capabilities.

Specific power, specific cost, and design life were the parameters chosen to describe the evolution of solar array technology. Technology readiness dates shown represent Level 6 state of development.

Specific Power (Fig. 1.1). Array specific power output has improved from 5.7 W/kg capability for Skylab to the current state-of-the-art capability of 30 W/kg.

Solar electric propulsion (SEP) capability (1985) is forecast to be about 66 W/kg. Improvements in ultrathin cell (silicon or gallium arsenide) efficiency and radiation resistance along with the development of lightweight structures should boost specific power higher than 120 W/kg by 1990. Technology breakthroughs in solar cells now being tested in the laboratory coupled with concentrator-enhanced solar array developments could increase capabilities by 1990 to greater than 200-250 W/kg. Gains to several times that level might be possible in the middle 1990s if all the possible developments now foreseen were to reach maturation.

Specific Costs (Fig. 1.2). Specific costs of current solar arrays are approximately \$600/W. Higher power arrays such as SEP ($\sim$25 kW) which allow the use of semi-automated assembly processes and standardized cells, covers, and interconnects could reduce those costs to \$250-300/W. Further reductions in cost are expected to come from the use of larger area solar cells. At this time, a number of approaches to low cost

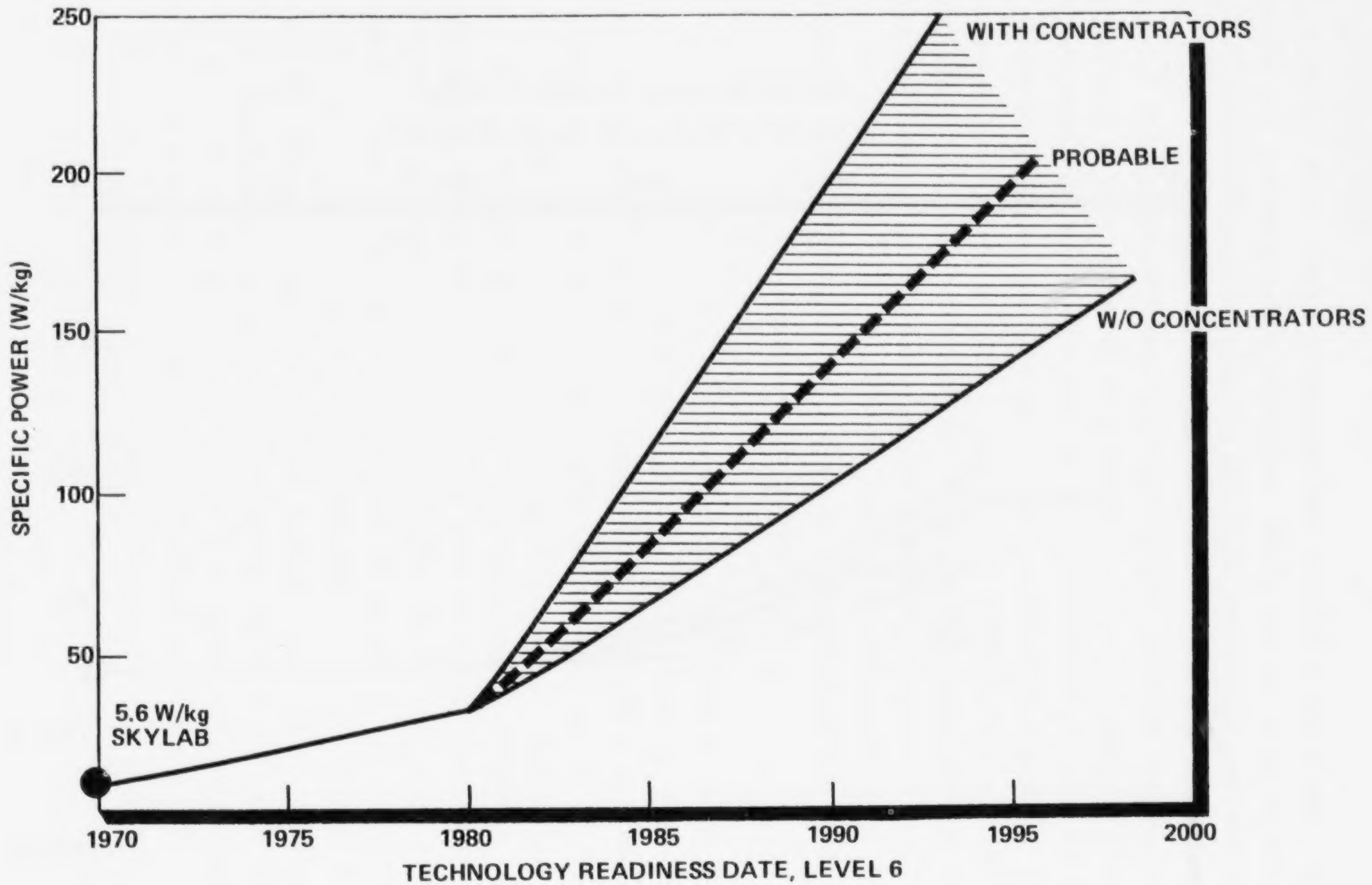

Figure 1.1. Specific Power of Solar Arrays

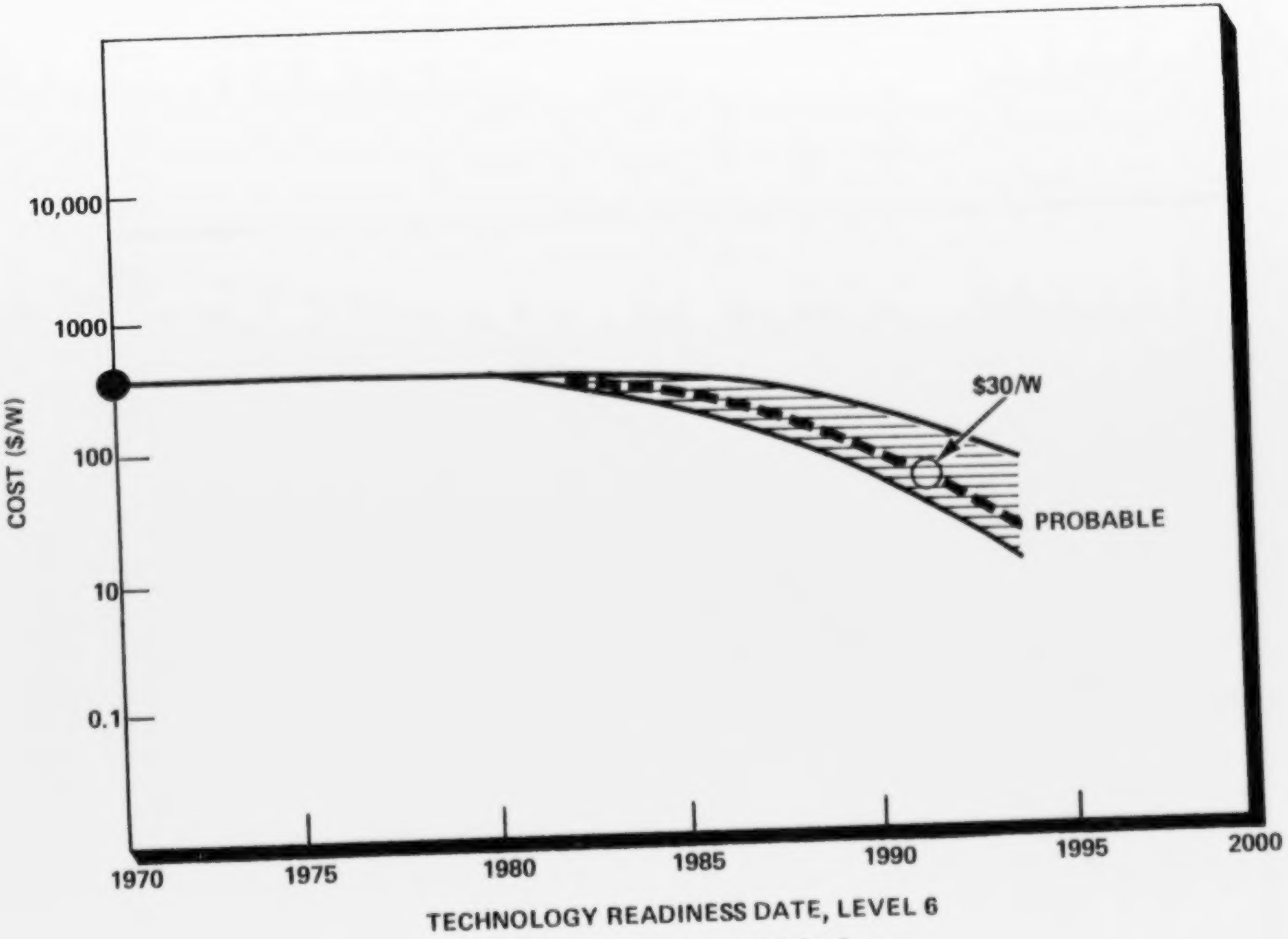

Figure 1.2. Specific Cost of Solar Arrays

blanket and array design to achieve less than $30/W for large scale solar arrays are presently being evaluated. While the lead role in reducing solar cell costs resides with the DOE, NASA continually monitors that effort for developments of potential benefit to space cells. That promise does exist as demonstrated by recent work which suggests that lower cost silicon material developed for terrestrial use may be indistinguishable in performance from space quality single crystal material. Gallium arsenide cells, although projected to be more expensive than silicon, can operate at higher temperatures allowing the utilization of solar concentrators. Through the use of low-cost concentration systems gallium arsenide arrays with fewer and more efficient solar cells have the potential for significant cost reductions. Further radical reductions in array costs would be predicated on substantial revision of methods of procuring and of operational procedure.

Design Life (Fig. 1.3). A good figure of merit for solar array operating life is the power per unit area delivered after a specific mission duration. Silicon cells now produce over 50% more power per unit area after 7 years in GEO than they did in 1970 (17 mW/cm^2 vs. 11 mW/cm^2). Optimistically, if in-situ annealing proves feasible, design life could be extended indefinitely by 1990. This technology development would effectively eliminate the solar array as a critical, constraining spacecraft component for long-duration missions. Other approaches to reduce radiation damage are also being pursued in the event annealing proves impractical. This work should increase power output to beyond 20 mW/cm^2 by 1990. Expressed another way, one current target of the OAST program is to reduce output power loss to less than 15% after 10 years in GEO. For purposes of the projection of Fig. 1.3, design life terminates when output power degrades to 75% beginning of life power for a GEO mission.

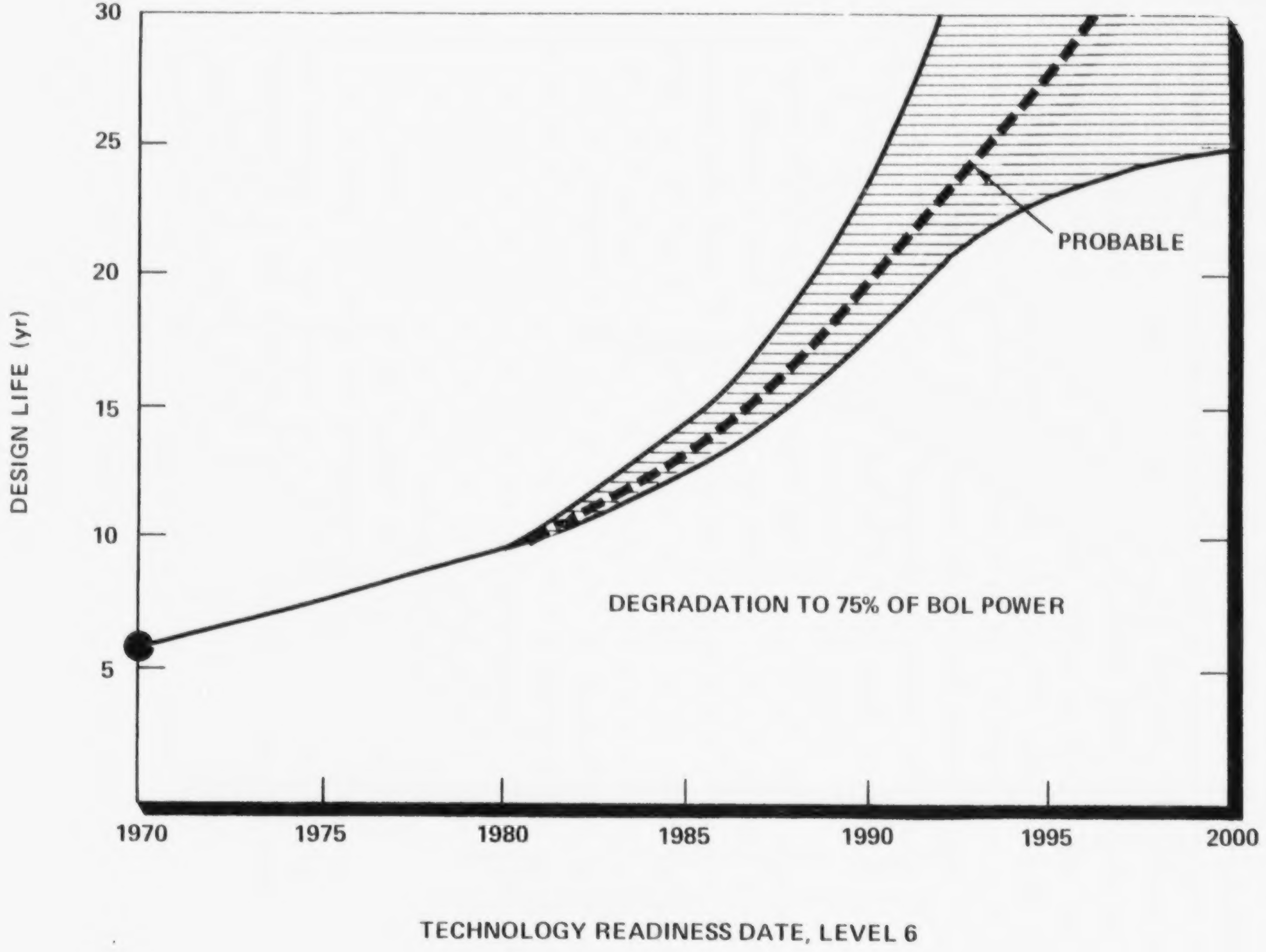

Figure 1.3. Design Life of Solar Arrays

1.2 SPACE ENERGY CONVERSION AND STORAGE: TECHNOLOGY PROJECTIONS

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1.2.1 Batteries

Several government agencies and private contractors are developing primary and rechargeable or secondary electrochemical storage batteries with the goal of achieving low-cost, long-life, and high-energy density per unit weight. However, many of the systems are not compatible with the space environment or NASA's requirements. Among the potential systems are the alkali metal high-energy couples under development since the late 60s, which for brevity will all be lumped together as Na/X, Li/X. This designation actually includes a wide range of low- and high-temperature alkali metal concepts with different positive electrodes, X. At this time, a very substantial effort is being expended on their development.

Four systems, nickel-cadmium (Ni/Cd), nickel-hydrogen (Ni/H_2), and the Na/X, Li/X high-energy group are the most promising in relation to future space needs. However, it appears that, in order for the sodium and lithium systems to become usable and reliable storage batteries, particularly high-rate secondaries, significant resources must be spent to bring them to reality within the next 20 years. A significant effort is necessary to bring Ni/H_2 to the level of technical development of the Ni/Cd system technology. For long life and low cost, Ni/Cd must still be considered seriously. Ni/H_2 appears to have potential for geosynchronous and possibly low earth orbit, but this will only become evident in the near future when a broader data base is accumulated. The alkali metal systems are potentially lightweight but not necessarily low cost or long lived.

During the first two decades of the space era, Ag/Zn was the most common primary battery, although the majority of orbiting spacecraft contained Ni/Cd secondary batteries as their energy storage system. The choice of this electrochemical system over others was based primarily on the following factors:

(a) High cycle capability
(b) Simple charge control requirements
(c) Reasonable specific energy
(d) Good reliability

During the late 50s and early 60s there was a considerable effort put into the development of the Ni/Cd system. The driving force for this effort was caused by the increased mission requirements placed on the orbiting spacecraft. Six-month mission goals quickly developed into four year missions as success followed success. Spacecraft became "operational" vehicles rather than scientific experiments, and the requirements on the energy storage system forced development to the present state of the art.

During the decade 1957-1967, the development efforts for Ni/Cd systems concentrated on the following areas:

(a) Terminal seal
(b) Separator
(c) Design parameters, such as negative-to-positive capacity ratio
(d) Cell pressure

Successful development work in these areas resulted in considerable and significant improvement in the Ni/Cd system. At the same time that this development was proceeding, many life cycling programs were being conducted in order to establish a credible data base which would be used in both life predictions and the associated reliability factors.

The Ni/Cd battery system has become sophisticated because the required data base was developed. The effort included:

(a) Continued development of nickel electrodes which led to new impregnation techniques, and in turn, resulted in superior electrodes.

(b) Power system designers learned to operate within the constraints of the Ni/Cd system, and thus the life cycling results of the batteries improved significantly.

(c) Cell manufacturers improved their quality control significantly because of the various pressures imposed on them by the Government agencies.

(d) Users have learned techniques of extending the service life of the Ni/Cd batteries by various techniques, i.e., deep discharge reconditioning, low temperature operation.

In the late 60s, initial development was begun on the secondary Ni/H_2 cell, which combined the best electrodes known to electrochemical conversion system developers with respect to rate and cycle life capability. This system has continued to evolve and is rapidly gaining acceptance among the space community for flight application. It offers higher energy density and long life at deep depths of discharge.

Since 1970, important progress has been made in the field of energy storage. This is attributed to discovery of novel methods of utilizing the high-energy alkali metals, both sodium and lithium, in both primary and secondary systems. At the present time, a great deal of work is in progress to develop practical cells based on these high-energy anodes.

The important parameters which characterize space batteries are storage capacity and design life. Storage capacity is a measure of the battery's energy density and is expressed in terms of watt-hours/kilogram. Design life is the number of years the battery can operate continuously within the required voltage limits in the case of rechargeable or secondary systems, and the number of years a battery can be stored and still deliver full capacity in the case of primary systems. When defining the design life, the type of cycling regime and the orbit are usually described. Costs also become increasingly important as total storage capacities increase to the level of many tens of kilowatt hours and larger.

1.2.1.1 Storage Capacity

Primaries. The silver-zinc (Ag/Zn) system is the most common primary battery is use. It can now deliver about 150 W-h/kg depending upon the application. Some improvement can be expected. Over the past several years, lithium primaries based on SO_2 and $SOCl_2$ have been developed. Of these, the $SOCl_2$ system is likely to find the most space application. Figure 1.4 displays the projections. It shows a forecast of the specific energy density of primary batteries utilized for space application through the 1980s. It is expected that the specific energy density of the $Li/SOCl_2$ battery will increase from 150 to 300 W-h/kg by the late 1980s.

Secondaries. Projections of the storage capacities of the system of interest have not changed considerably over the years. The largest gains should be possible in the more energetic systems such as Li/X and Na/X with modest gains still possible in the Ni/H_2 and Ni/Cd systems.

The Na and Li systems should improve with more development. Improvements in materials, packaging, and operating techniques should all raise the storage capacity. Without improvements in these areas only modest gains will result, due to the need to reduce depth of discharge (DOD) to achieve greater life.

The Ni/Cd and Ni/H_2 system will achieve modest gains from packaging and electrode improvements, and extensive effort will be needed to realize significant advances. To meet NASA's projected capacity requirements, a change from Ni/Cd to Ni/H_2 and finally to high-energy systems is likely. It is expected that the high-energy systems will increase from 40 to 250 W-h/kg over the next two decades.

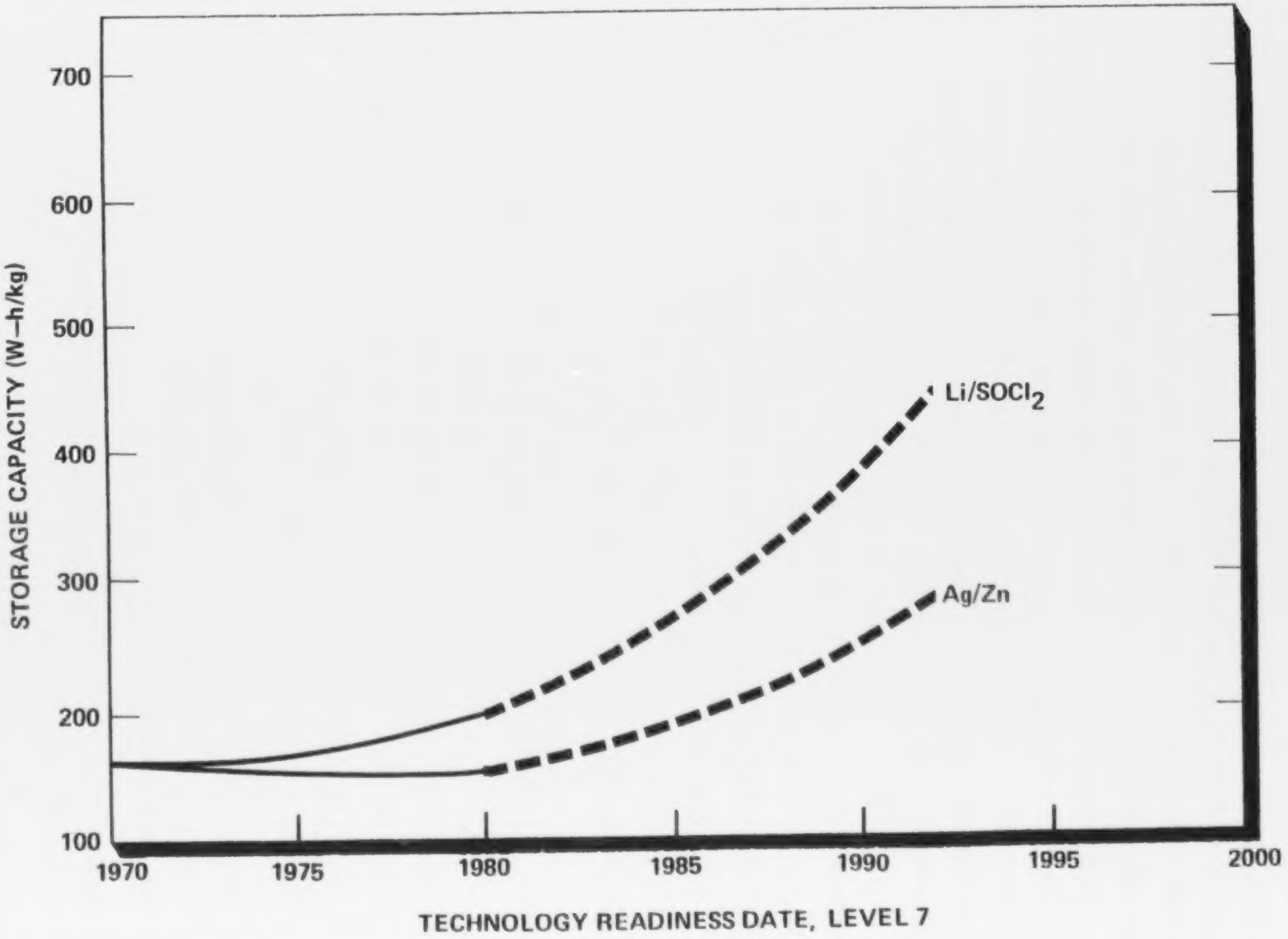

Figure 1.4. Primary Battery Storage Capacity

Ni/Cd. In order to determine the improvements possible in an existing system such as Ni/Cd, a base point must be established; unfortunately this base is a function of usage. A standard GE 20 cell used in many flight programs weighs 950 g and delivers a minimum of 24 A-h at an average of approximately 1.2 V. This results in a cell capability of 30.3 W/kg. In terms of a packaged battery, using standard packaging techniques, this figure is reduced to 24.3 W-h/kg packaged specific energy density. For a low earth orbit in general the depth of discharge has been restricted to 20% for missions exceeding 1 yr, and thus the useful energy density of a Ni/Cd battery is 4.9 W-h/kg. However, in the case of a geosynchronous orbit, where the same battery can perform at a 60% depth of discharge, the useful energy density is 14.6 W-h/kg. Ni/Cd batteries which are used in planetary missions are also considered to have a useful energy density approximately 60% of the battery output, and thus it is similar to the case of the geosynchronous orbit. We can establish three base points of reference for useful energy density:

Low Earth Orbit: 4.9 W-h/kg
Geosynchronous Orbit: 14.6 W-h/kg
Planetary Mission: 14.6 W-h/kg

In order to improve this state of the art, the following steps can be taken:

1. Reduce the cell weight by reducing the mass of the cell case walls.
2. Reduce the battery assembly structural weight from 25% of cell weight toward a goal of 5%.
3. Change the plate manufacturing process to improve the sintered nickel plate, and the utilization of the active materials.
4. Improve the utilization by application of reconditioning techniques.
5. Improve the life predictability.

Lightweight flight-battery design is being developed to take care of items 1 and 2. It is estimated that overall battery energy density can be increased from the present 24.3 W-h/kg to 40 W-h/kg within about 2 yr with these improvements. Reconditioning techniques will most likely gain widespread acceptance over the next few years, and this technique will increase the useful depth of discharge in geosynchronous orbit regimes from 60% to 80%. We can also expect the present 20% depth of discharge for low earth orbit regimes to increase to approximately 40% within the next few years. Thus, the immediate forecast for useful specific energy for the Ni/Cd system within a 2-3 yr period is as shown below. The 1982 estimates appear to be close to the practical upper limit of Ni/Cd capability.

	Present (W-h/kg)	1982 (W-h/kg)
Low Earth Orbit	4.9	16.0
Geosynchronous Orbit	14.6	32.0

Ni/H_2. Continued progress is being made with the Ni/H_2 cell. The packaged energy density is presently about 45 W-h/kg, for systems utilizing 50 A-h Ni/H_2 cells. This figure may be improved when much larger cells are designed and utilized. It is obvious that, unless the Ni/H_2 system improves its rated energy density, it holds little weight advantage over the forthcoming Ni/Cd systems for geosynchronous orbit regimes. However, it is forecast that this new system will be able to utilize about 60% of its specific energy during a low earth orbit regime, and thus would present a significant weight gain over the 1982 Ni/Cd useful specific energy. Thus, the useful specific energy for the Ni/H_2 packaged system by 1982 is expected to be:

Low Earth Orbit: 31.5 W-h/kg
Geosynchronous Orbit: 36.0 W-h/kg

It is also forecast that the Ni/H_2 system will inherently have even better reliability than the Ni/Cd system, and it also will be a more "forgiving" system with simpler system requirements.

Na/X, Li/X--High-Energy Systems. Among the candidate systems in this group are ambient temperature organic electrolyte lithium/transition metal dichalcogenide (e.g., TiS_2) cells, moderate-temperature (100-170°C) sodium/dichalcogenide (e.g., TiS_3, VS_3) cells with solid electrolyte containment of the liquid negative, and the high-temperature molten salt batteries (350-400°C) using sodium/sulfur (several configurations under development) and lithium/iron sulfide. Extensive work in the high-temperature concepts for terrestrial applications has 200 W-h/kg as the goal for 1989 (Ref. 5) load leveling applications.

These systems range in energy density from 60 to 150 W-h/kg at the present time. It is anticipated that this can improve to a range of 100-250 W-h/kg in the future. These systems will produce energy storage sufficient to meet NASA requirements near the end of the century. Considerable effort is necessary to realize these goals. Not enough is known of the systems to predict the best applications for this technology. Significant advances must be made in many key components to provide reliable unatttended operation suitable for space application. So far, most development has been performed only at the single cell level and projections have been made on this basis rather than projected for usage in battery systems.

1.2.1.2 Design Life

Primaries. The silver-zinc (Ag/Zn) system has a maximum design life of about five years or less depending on the conditions. Not much improvement is expected. For the $Li/SOCl_2$ system, improvements in separators and stability characteristics of the depolarizing electrolyte should provide improvement. Figure 1.5 displays the projections. It gives a forecast for the design life of primary space application batteries. It is expected that the life will be increased from about 3 to 10 yr by the late 1980s.

Secondaries. The only system with any demonstrated life is the Ni/Cd in both LEO and GEO applications. Many feel that the Ni/H_2 is capable of better performance in terms of life. The system appears to

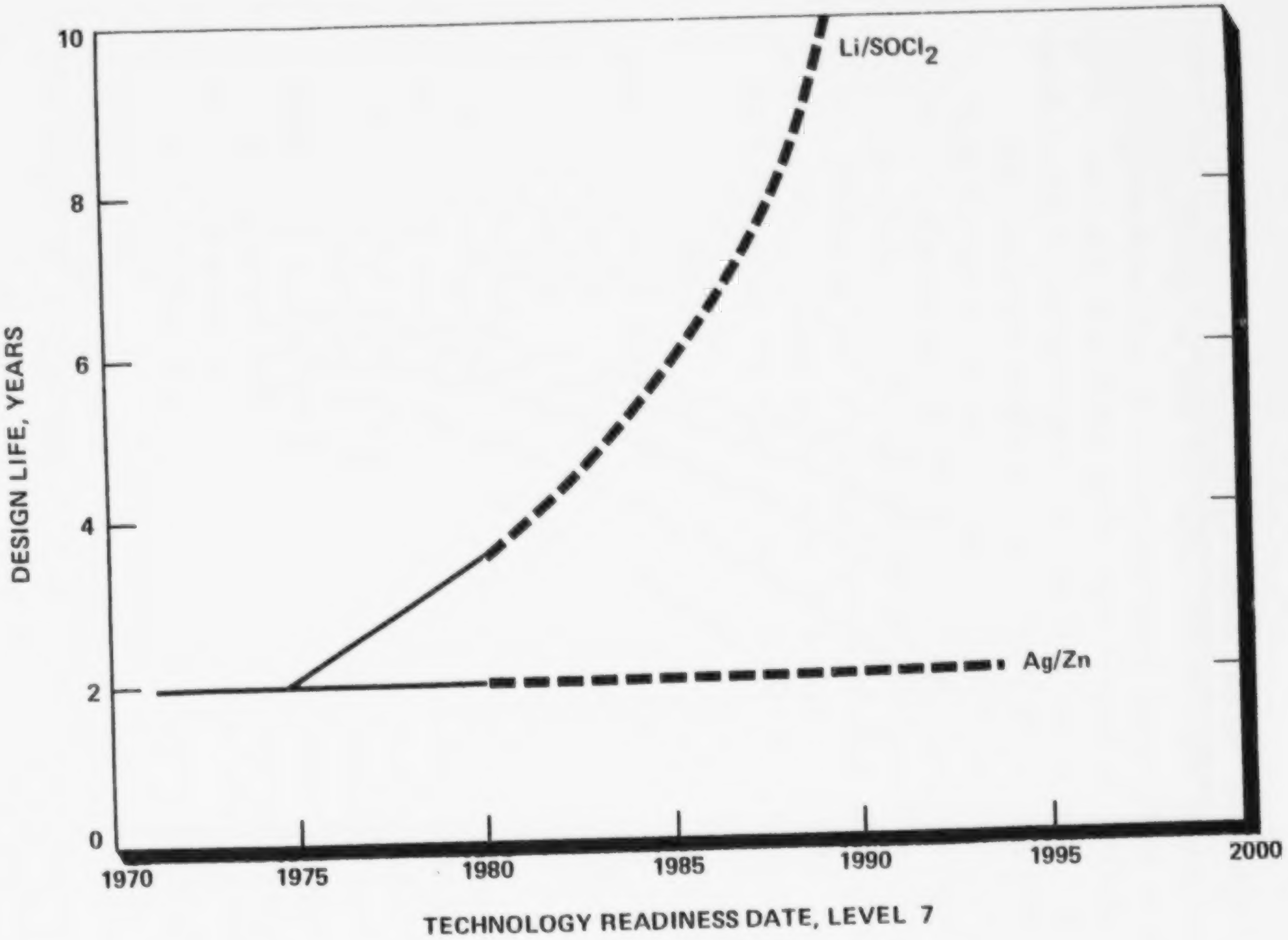

Figure 1.5. Primary Battery Design Life

work well in GEO with less of a probability in LEO. However, these systems appear to be the only two systems that will give up to 10+ years of service within the next 20 years.

The high-energy systems do not appear to be able to perform well for long periods of time, and this capability does not appear to be forthcoming in the near future. These systems will be lightweight but relatively short-lived in the near term. It is not expected that low-temperature lithium systems will last any longer than silver-zinc although they will be lighter. The high-temperature systems are plagued by materials and control problems, and results reported in the literature present activated lives of 4 to 25 months, but not as batteries. Most of the cells have small capacities (25-40 A-h). When cells are made into batteries lives decrease dramatically due to cell variations. It is difficult to predict when and if these systems will find use, but it is felt that they will not be available for space use in the next 10-15 years.

Figures 1.6, 1.7, and 1.8 display the projections of the life parameters: cell mean cycle life, design life at low earth orbit, and geosynchronous.

Variation in performance can be expected depending on the use in either LEO or GEO. Therefore, the curves reflect activated life and the time frame within which these systems can be expected to operate. Not enough is known in the high-energy systems of the relation of a small number of deep cycles (800) over a long period of time or a large number of shallow cycles over the same period. It will take dramatic breakthroughs to bring these systems to a point where they can operate safely and reliably as a battery for long periods of time with no maintenance.

Figure 1.6 describes the present state of the art for the Ni/Cd system in low earth orbit applications. It shows the cell mean cycle life as a function of depth of discharge and operating temperature, and the figure is included to emphasize the importance of temperature and

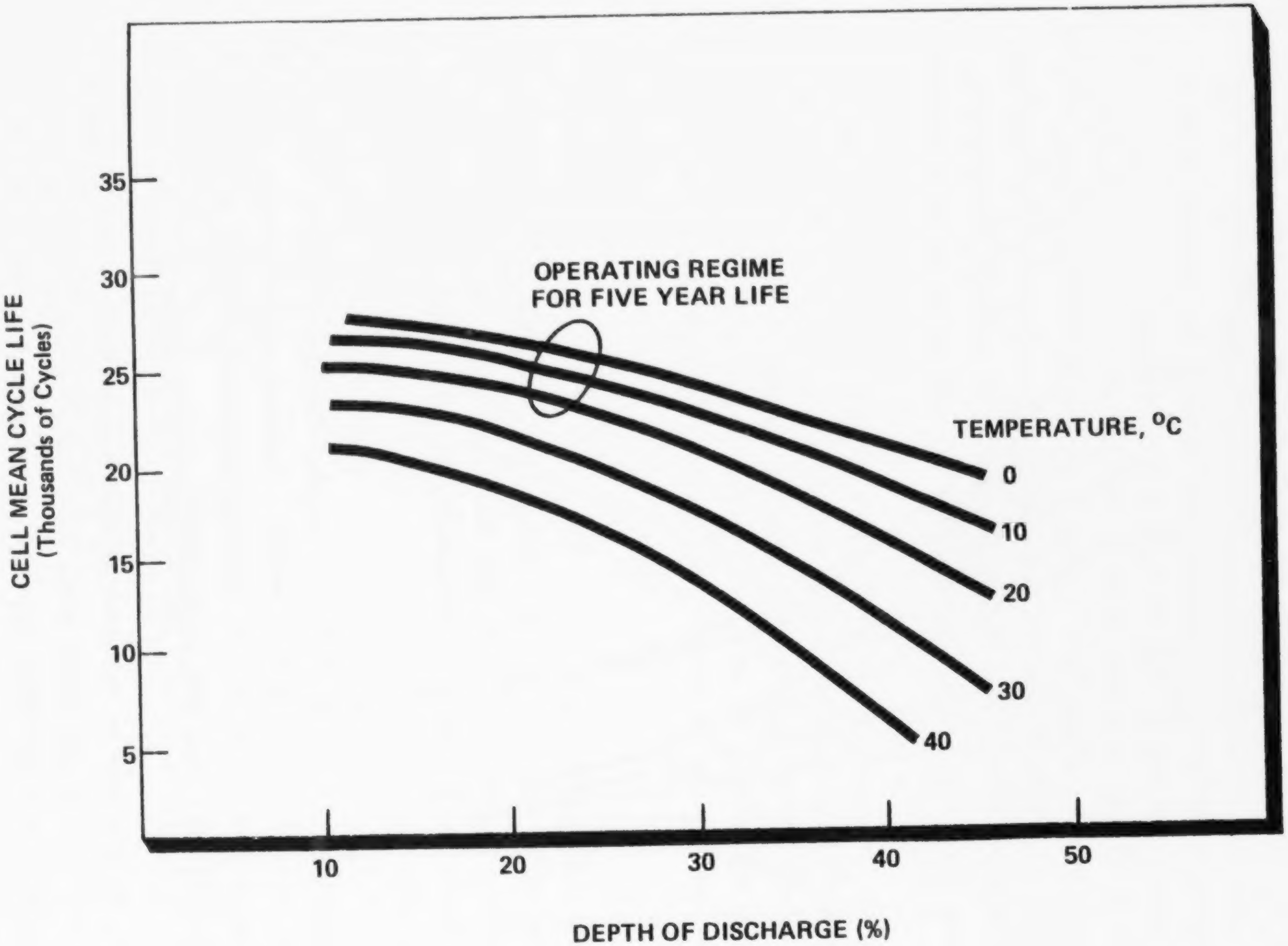

Figure 1.6. Secondary Battery Cycle Life at Various Temperatures – Ni/Cd (Low Earth Orbit)

and depth of discharge for this type of application. This type of curve is further influenced by cell reliability factors at the various depths of discharge and temperatures, and makes the present choice of 20% depth of discharge at temperatures between 0°C and 20°C obligatory for 5 yr of life.

Figure 1.7 projects the design life forecast for the Ni/Cd, Ni/H_2 and high-energy systems. For the high energy systems, life is shown over a range of depths of discharge in the low earth orbit regime. It shows the trends to longer life overall. At the same DOD for 1980 batteries, life will increase in the future while at increasing DODs they will maintain relatively the same life. As noted earlier, considerable uncertainty exists for Ni/H_2 particularly as data is yet to be developed.

Figure 1.8 projects the design life forecast for the Ni/Cd and Ni/H_2 system at 60-80% depth of discharge and in geosynchronous orbit regime. It shows a significant improvement from the present 5-yr life to 10-yr life by the mid 1980s. While not reflected on the plot it is to be noted that appreciable uncertainty exists for the Ni/H_2 system at this time.

1.2.1.3 Cost ($/kW-h)

Primaries. The major space application for primary cells is in manned spacecraft auxiliary power and planetary probe batteries. Cost is not a particularly important parameter for these applications and is not projected.

Secondaries. Cost is difficult to project when comparing known systems vs. systems in early development. However, the consensus is that all systems will decrease in cost omitting inflation ($/kW-h) due to increases in life, use, and DOD developments.

Ni/H_2 is expected to decrease in cost because it is now a handmade cell. Moving it from the model shop, a dedicated manufacturer and the learning curve should decrease its cost. It does not appear that the

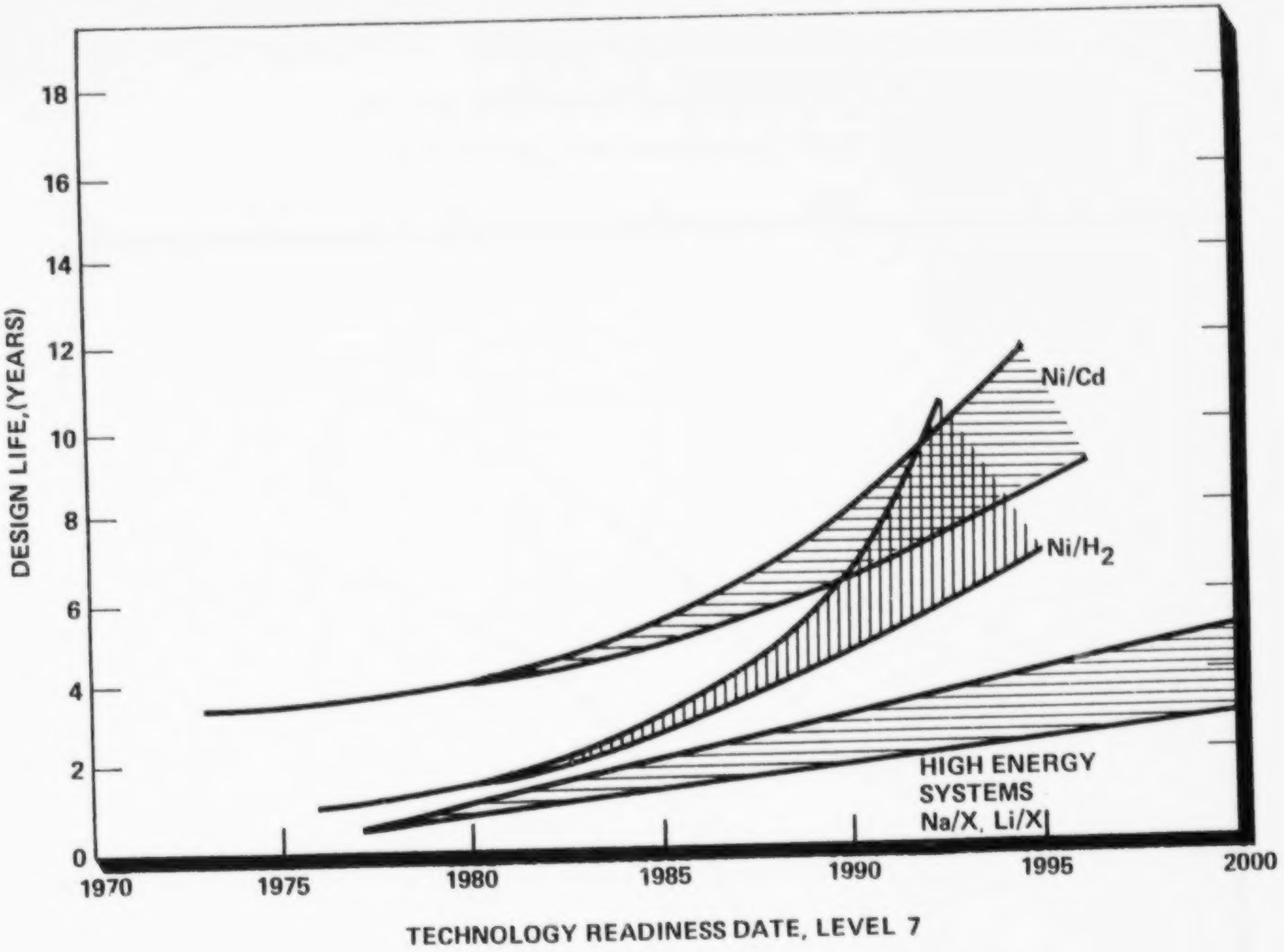

Figure 1.7. Secondary Batteries Design Life (Low Earth Orbit)

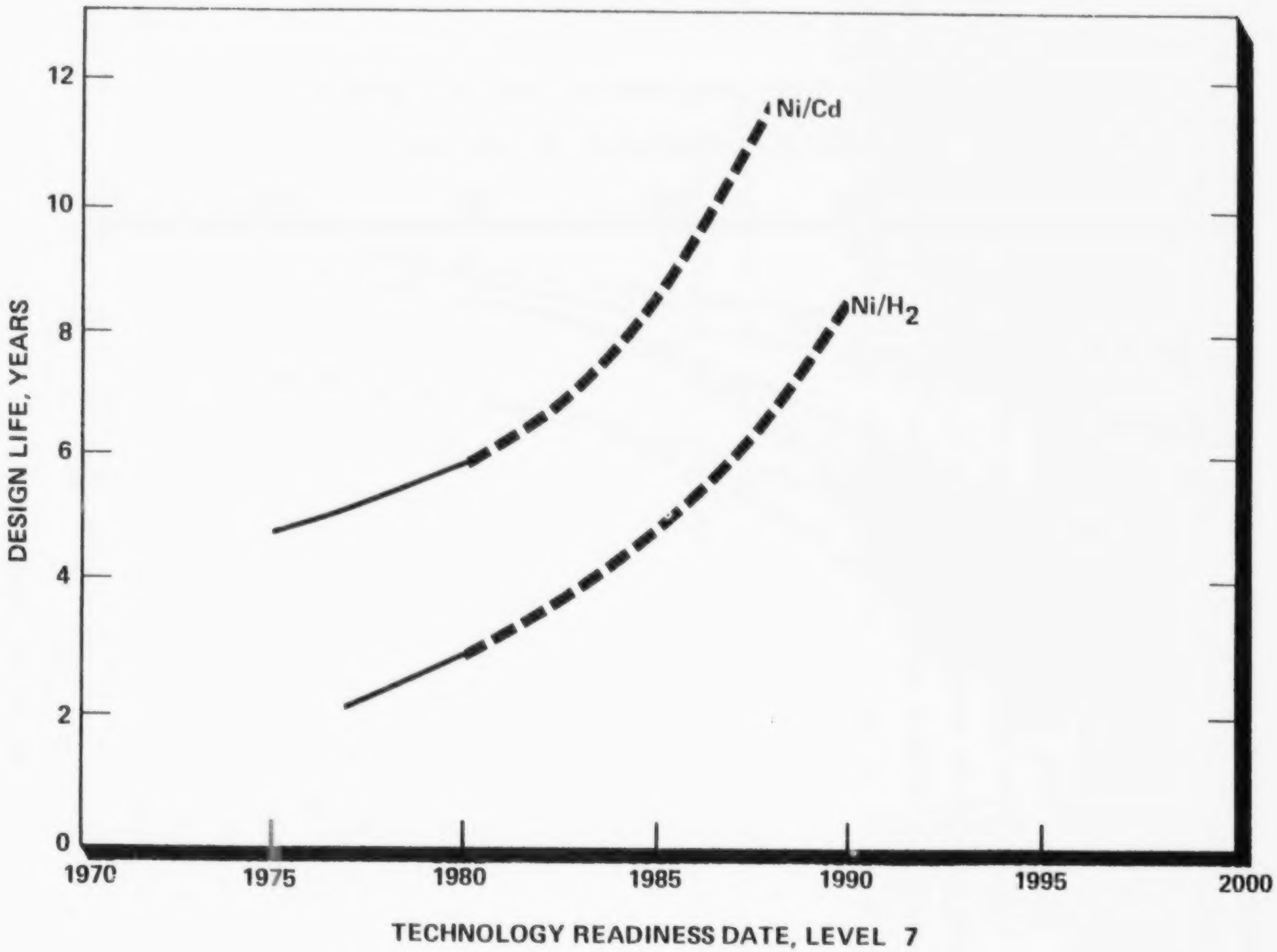

Figure 1.8. Battery Design Life (Geosynchronous Orbit)

system will become a high-volume product; therefore, it is expected to remain relatively costly. The high-energy systems are costly, but published projections show dramatic decreases dependent on mass production. However, the space cell will still be more costly than its terrestrial counterpart by 2.5-10 times, depending on capacity and extent of use. Figure 1.9 provides a projection.

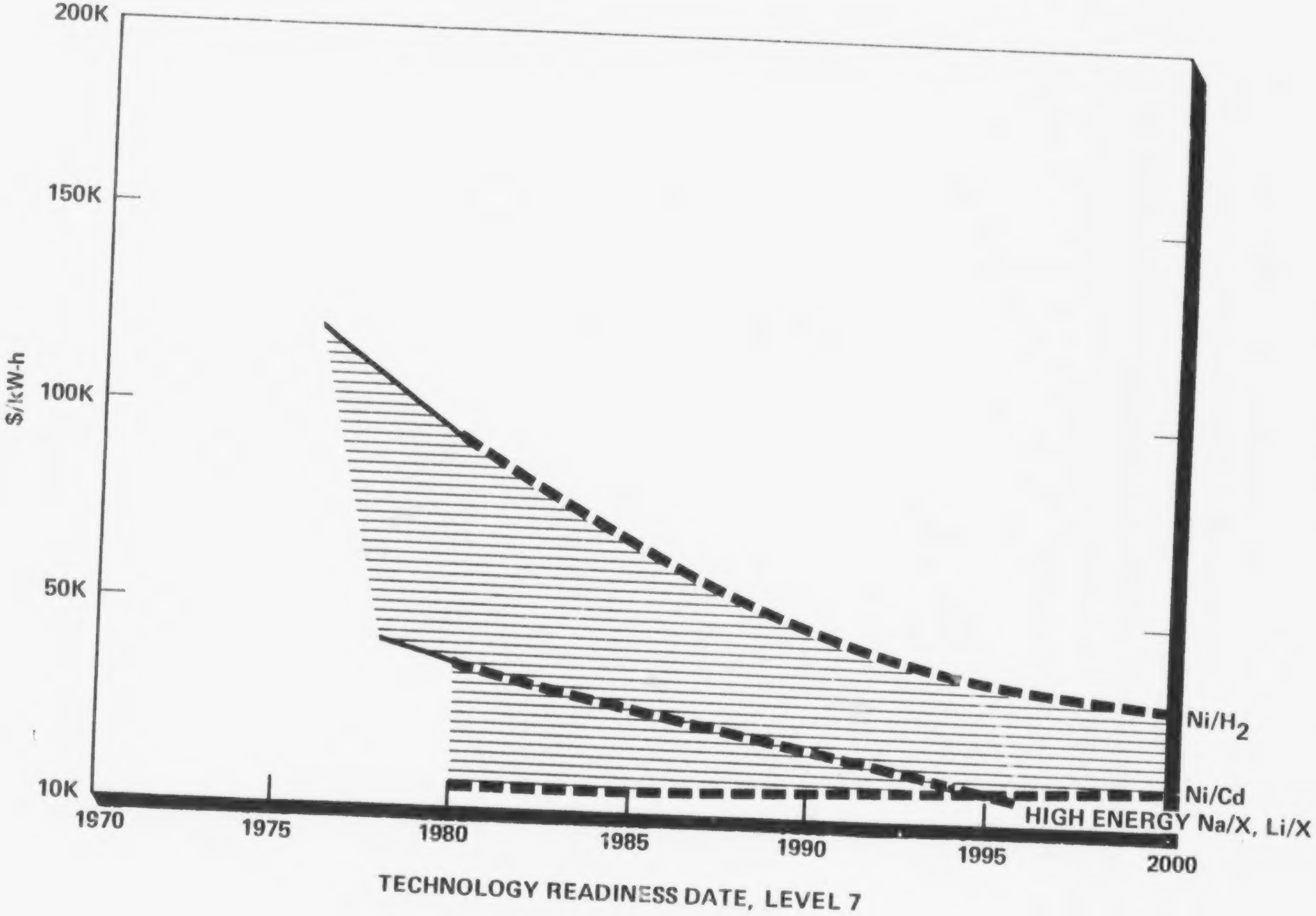

Figure 1.9. Secondary Battery Specific Cost

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1. Energy Storage Systems for Automobile Propulsion, VCRL-52303, 15 December 1977, Contract W7405-Eng 8, Lawrence Livermore Laboratory.

2. A Collection of Technical Papers - AIAA/NASA Conference on Advanced Technology for Future Space Systems, 8-10 May 1979.

3. L. W. Sifer and W. J. Billerbeck, Synchronous Orbit Power Needs, NASA Technical Memo 80280, April 1979.

4. Future Orbital Power Systems Technology Requirements, NASA Conference Publication 2058, Symposium held at LeRC, 31 May-1 June 1978.

5. DOE Battery and Electrochemical Contractors Conference Publication, Volume II, 10-12 December 1979, held at Arlington, Virginia.

1.2.2 Fuel Cells

Fuel cells are presently used as power sources for the Shuttle and are envisioned as auxiliary power sources for orbital transfer vehicles (OTVs). Fuel cells integrated with an electrolyzer unit present attractive weight savings for low earth orbiting (LEO) satellites requiring multikilowatt energy storage.[1] Applicable parameters for the fuel cell power generation application are specific cost ($/We), power level (kW), specific power (W/kg), and design life. For the fuel cell-electrolyzer units for energy storage, the useful parameters are storage capacity (W-h/kg), design life (h), and specific cost ($/kW-h).

The present state-of-the-art space technology is exemplified by the alkaline electrolyte Shuttle Orbiter fuel cells, the lightweight fuel cell stack developed for future OTV applications developed by United Technologies Corporation and the solid polymer electrolyte (SPE) orbiter demonstration units, and SPE electrolysis units developed by General Electric. The orbiter fuel cell is at a flight readiness level; the lightweight OTV stack initial developmental testing is to begin in early 1980. Cost estimates are very nebulous. A study recently initiated[2] should help provide these figures, but no data are available as yet. However, orbiter fuel cells were built for delivery several years ago[3] at $40/W, and a lightweight stack could probably be built now for that figure. The orbiter stack operating on dedicated cryogenic reactants H_2 and O_2 was designed for a peak power of 12 kW with brief overloads to 15 kW and an average of 4.5 kW; however, the average load has now been pushed up to ~7 kW. The lightweight OTV stack is designed to use propellant-grade H_2 and O_2 reactants at a maximum power of 3.5 kW with an average load of 2.2 kW. The other large alkaline fuel cells built have been for Deep Submergence Rescue Vehicles (DSRV) and have had power levels of

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[1] J. B. Trout, "Energy Storage for Low Earth Orbit Operations at High Power," Proceedings of AIAA/NASA Conference on Advanced Technology for Future Space Systems, 8-10 May 1979, Hampton Virginia.

[2] Energy Storage Subsystem Study, PRC Systems Service Company, Huntsville, Alabama, Contract NAS3-21962, (initiated 1 November 1979).

[3] R. E. Martin, United Technologies, Project Review, 30 January 1979.

20-35 kW. Specific power of these units is ~110 W/kg for the Shuttle fuel cell and ~150 W/kg for the lightweight OTV stack. These figures represent weights of the stack and accessories without power conditioning or gas supplies. Design life for the Shuttle power plant is 5000 h and for the OTV power plant 2500 h. The only present funding for development of space fuel cells (both SPE and alkaline) is found in the OAST 7-yr fuel cell-electrolyzer program being conducted by the Johnson Space Center and Lewis Research Center.

Terrestrial fuel cell systems are under development by the Department of Energy, Electric Power Research Institute, Gas Research Institute, and the Tennessee Valley Authority. The phosphoric acid system is the early entry with prototype modules from 40 kW to 10 MW to be ready for commercial entry be 1986. Technical feasibility units are going on test in 1980. By the early 1990s, the molten carbonate fuel cell for base load and cogeneration use in the megawatt to hundreds of megawatt size may be ready. The solid oxide electrolyte fuel cell may be available by the year 2000. It is uncertain what role, if any, these terrestrial fuel cell systems will play in future space activities but they illustrate the technological potential and offer potentially low-cost power generation at high efficiency.

The technology of combining fuel cells with electrolyzer units as an integrated system for energy storage is in the early development stage. Subscale units are currently being tested or about to be tested under LEO conditions, but a full breadboard model of the integrated system (6-7.5 kW) will not be tested for about 2 yr. Maximum power capability in LEO would probably be ~15 kW by 1985. Design life of the individual units at present could be estimated at 5000 h with possible improvement to 10,000-20,000 h by 1985.

A study has recently been completed[1] aimed at optimizing operating conditions, i.e., the pressures, temperatures, etc., of the various subsystems in order to minimize total weight of a storage system based on the SPE fuel cell and electrolyzer. Figures for alkaline components would probably be similar. From this study, a 35-100 kW system would weigh 35 kg/kW. This includes the recycling gas and water supplies, heat management, and the increase in the size of the solar array required due to the lower efficiency (20% less) of the fuel cell electrolyzer system compared to a battery system. To compare storage capacities for an individual orbit as is done for battery storage systems, with 0.6 h for the dark portion of each orbit, the result is 35 kg/0.6 kW-h, or 17 W-h/kg. If we consider only the weight of the fuel cell + electrolyzer units + gas storage without the thermal management and additional solar array penalty, we have a delivered storage capacity of 50 W-h/kg.

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[1] Electrochemical Cell Technology for Orbital Energy Storage, General Electric Company, Direct Energy Conversion Programs, Wilmington, Massachusetts, Contract NAS3-15831, Monthly Report #4, 10 September 1979 (summary report in preparation).

Costs can only be estimated based on the present technology, and to facilitate comparison with the battery system only the storage components which would be replaced are included. Using the orbiter fuel cell cost of $40K/kW, the cost of the fuel cell-electrolyzer system would be about $100K/kW. If we estimate the life of present components to be about 1 yr, the total specific cost is $28.5/kW-h and the specific cost per orbit is $167K/kW-h. For comparison: commercial systems for terrestrial application cost approximately $350/kW when mass produced. The studies now underway[1] should give a better estimate of these costs.

It should be emphasized that both the estimates of total specific cost ($/kW-h) and total storage capacity (W-h/kg) are based on only modest improvements in the life of the components. A doubling of life would double the total storage capacity and halve the total specific cost. Increases in efficiency, pressure, and temperature of operation would also improve these figures. The conditions of the LEO orbit enter into the above calculations, which were done assuming a light-to-dark ratio of 3/2.

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[1] Trout, op. cit.

The present state-of-the-art data and future trends are summarized in Figs. 1.10 through 1.13 for fuel cells and Figs. 1.14 through 1.16 for fuel cell-electrolyzer storage systems. Steady advances in technology are assumed. The earliest technology readiness date for the fuel cell electrolyzer system is shown as 1983 at the completion of the planned breadboard test. Specific costs for fuel cell electrolyzers are assumed to decrease as the size and number of units produced increases. Based on the GE study[1] which concluded that major reduction in weights of the fuel cell electrolyzer units and accessories were unlikely, a relatively slow increase is postulated in specific storage capacity per orbit as seen in Fig. 1.14.

It should be emphasized that the data base for space fuel cells and electrolyzers is very meager. The number of units and tests planned in the near future may not be sufficient to give reliable projections for a number of years.

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[1] GE Monthly Report #4, op. cit.

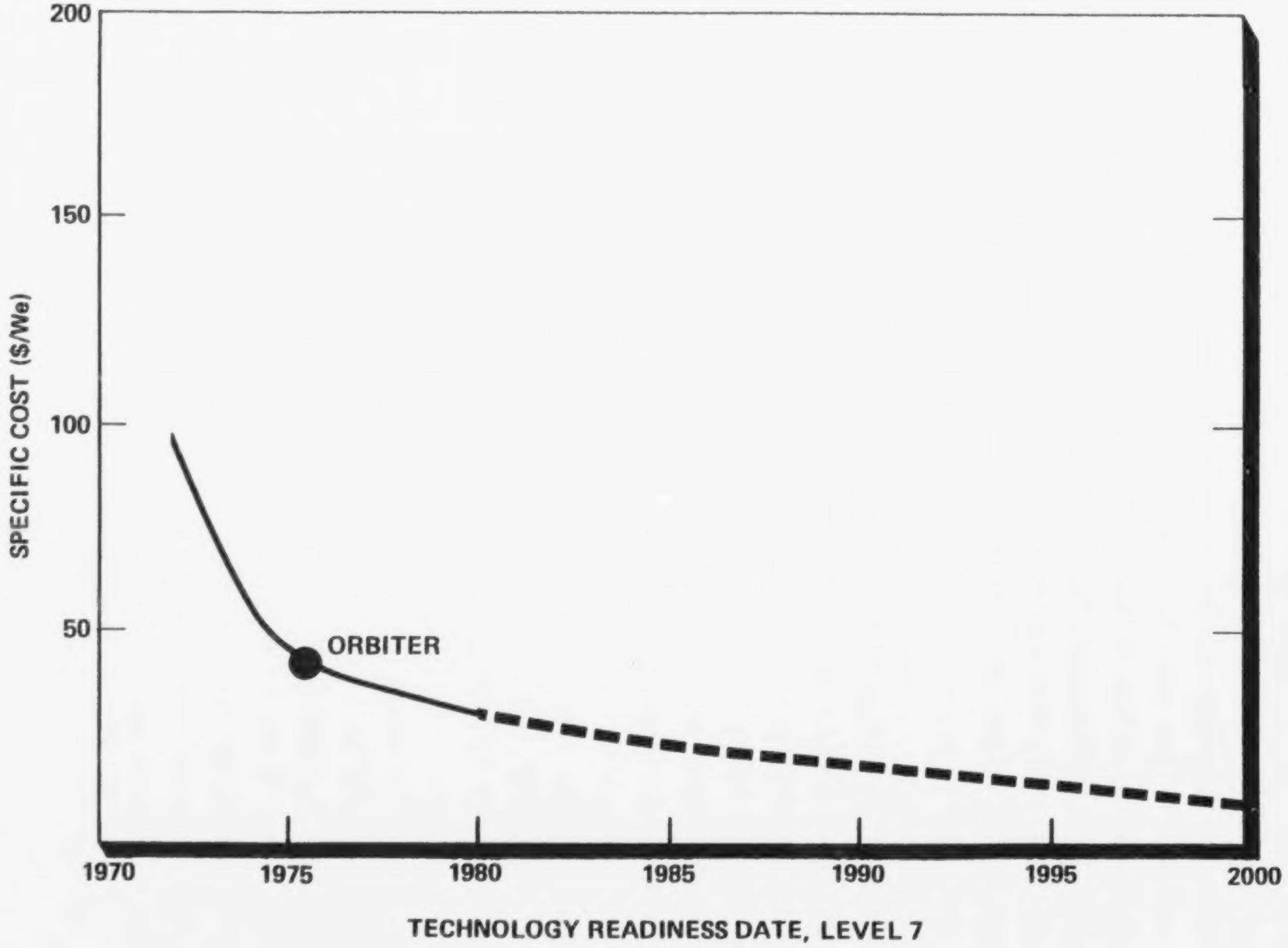

Figure 1.10. Fuel Cell Specific Cost

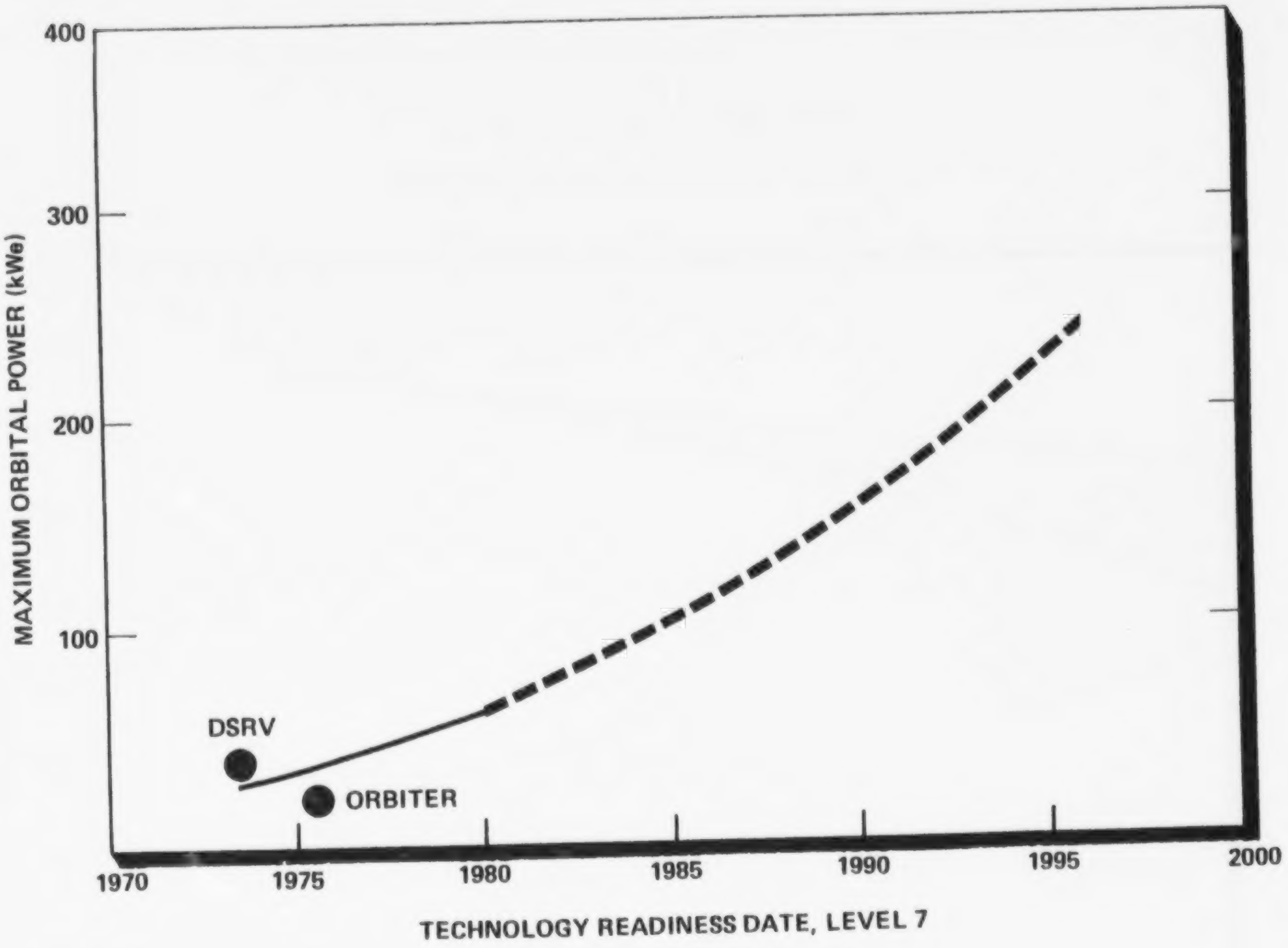

Figure 1.11. Fuel Cell Power Level

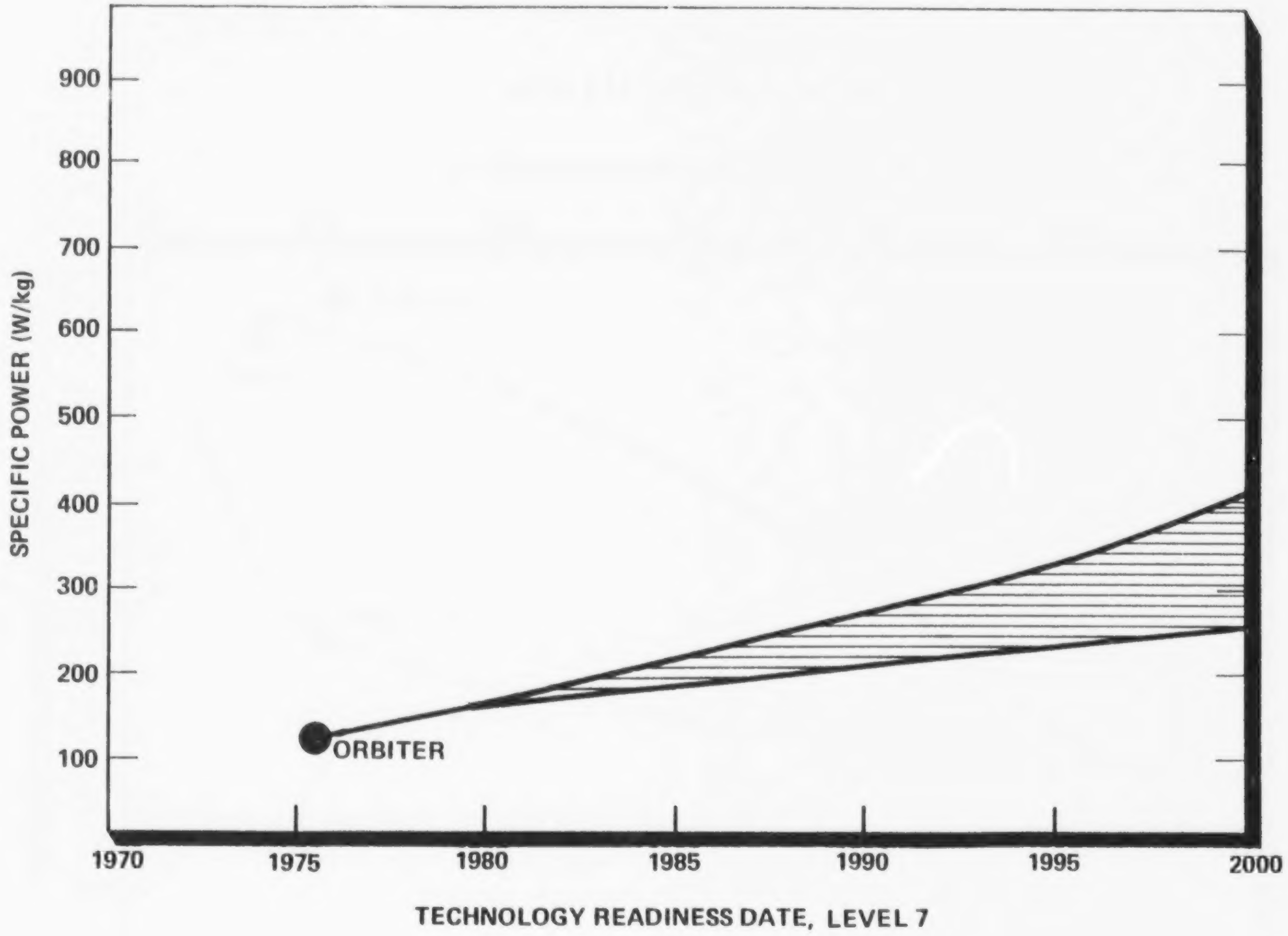

Figure 1.12. Fuel Cell Specific Power

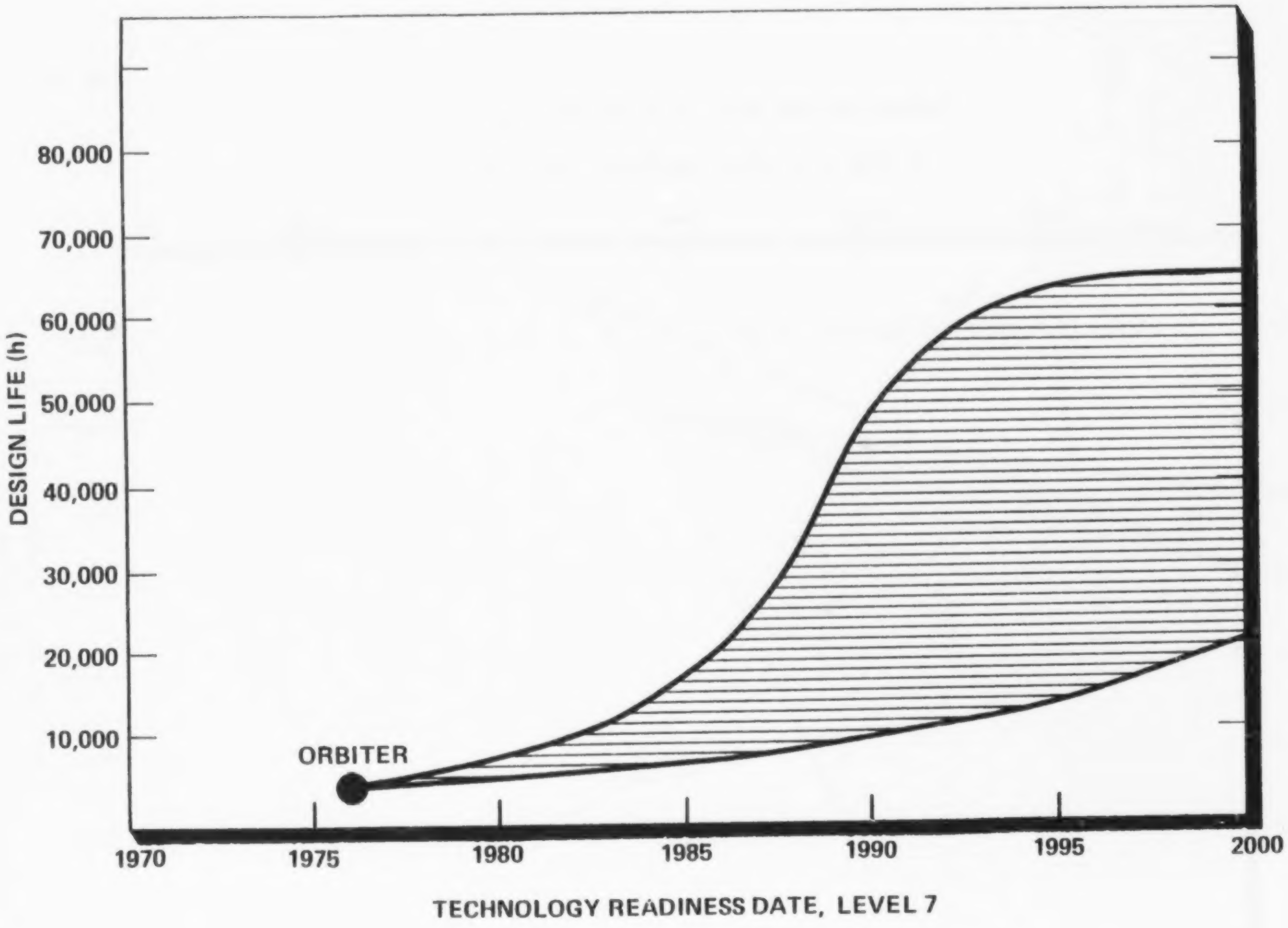

Figure 1.13. Fuel Cell Design Life

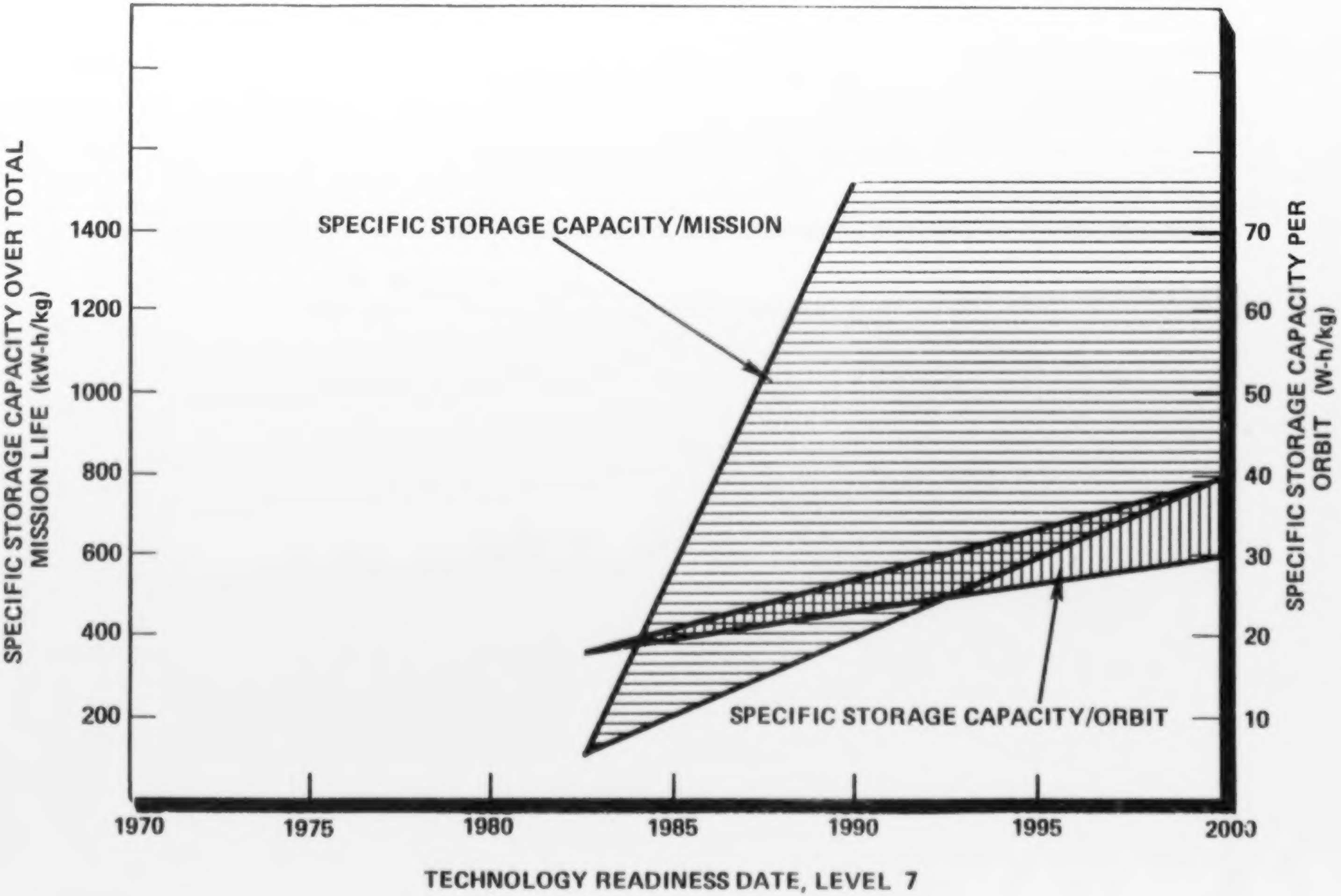

Figure 1.14. Fuel Cell Electrolyzer Storage Capacity

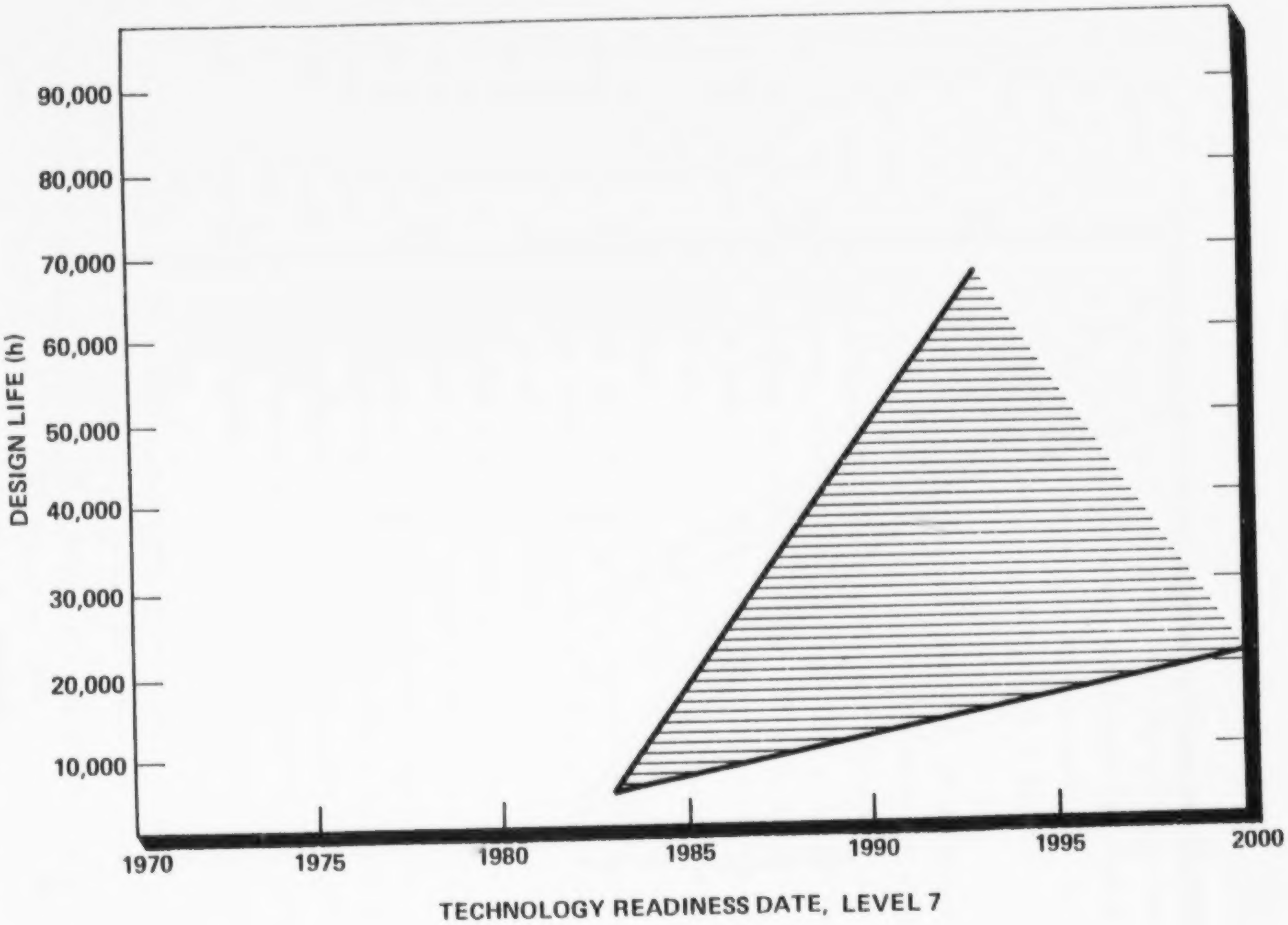

Figure 1.15. Fuel Cell Electrolyzer Design Life

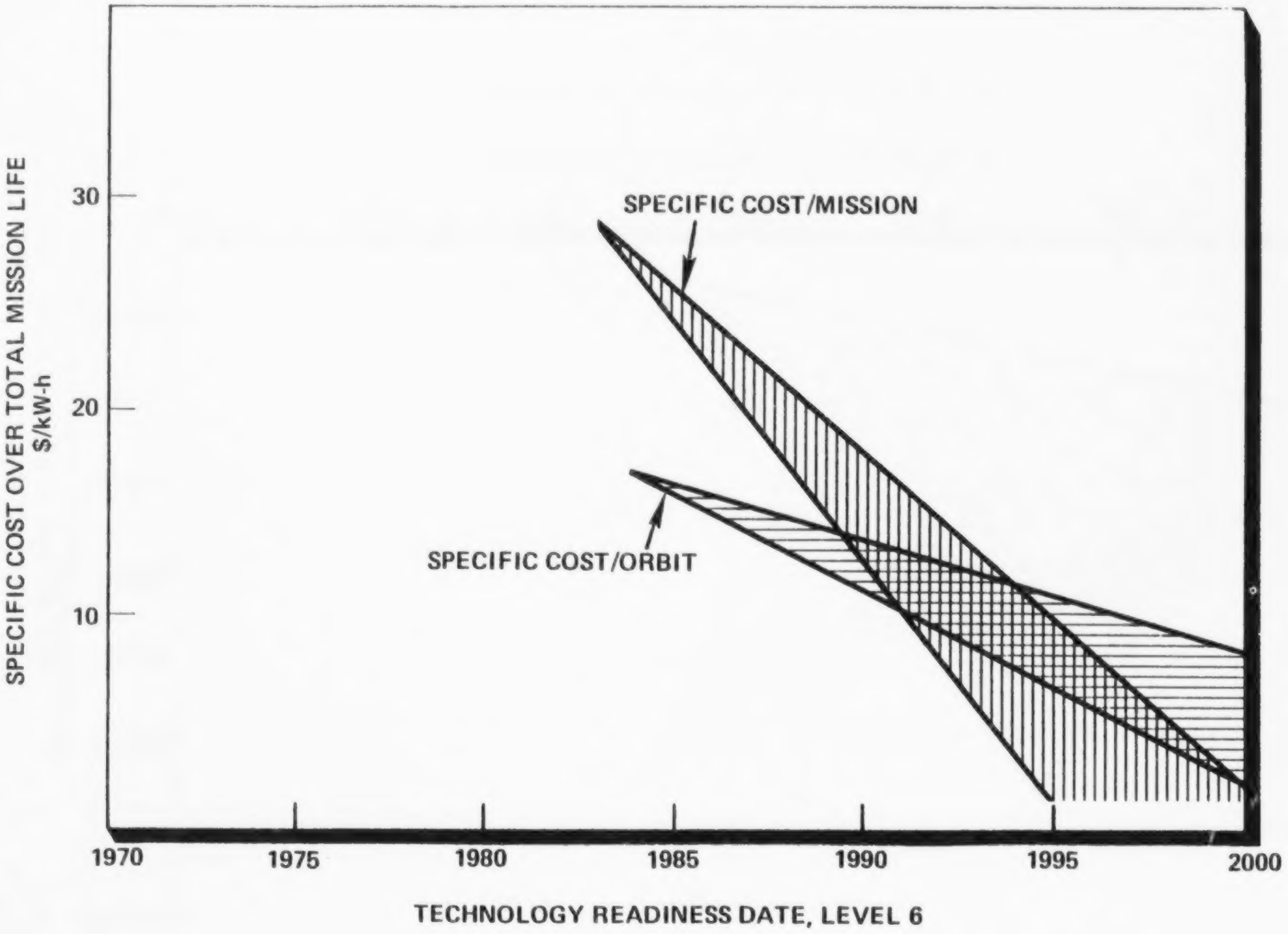

Figure 1.16. Fuel Cell Electrolyzer Specific Cost

1.3 THERMAL-TO-ELECTRIC CONVERSION

J. F. Mondt, Jet Propulsion Laboratory
B. J. Rock, Department of Energy

1.3.1 Space Power Reactor/Conversion Technology (J. F. Mondt, JPL; B. J. Rock, DOE)

Considerable past effort has been devoted to research on Rankine and Brayton cycle dynamic conversion systems. At the present time, emphasis is being placed on thermionic and thermoelectric conversion targeted at NASA nuclear electric propulsion applications and expected military and civil high orbit space power needs in the 1990s.

The NASA/JPL R&T development programs are directed at technology to raise the level of electric power available while reducing mass and volume, improving the efficiency of thermionic and thermoelectric converters, and increasing the lifetime of the converter components. The thermionic converter technology is approaching 12% efficiency at 1650 K emitter temperature. Efforts in thermionic research are being directed at improving efficiency and power density at 1650 K emitter temperature. Emitter and collector material screening effort is being conducted to select the materials for the converter. The screening is based on actual power performance data and electrode efficiency from operating converters. Development of thermoelectric materials with higher operating temperatures than 1300 K is also being investigated. The lanthanum, chromium, sulfide, selenide materials appear promising up to 1500 K. Silicon carbide is also possible for up to 1650 K. Development of thermoelectric materials or thermionic electrodes with 12 to 15% conversion efficiency would make an attractive 100-kWe nuclear power subsystem for low-thrust electric propulsion engines to be used for unmanned scientific exploration of our solar system and beyond.

Power Level (Fig. 1.17). For the outer planet missions, the maximum payload per single shuttle launch can be delivered by the maximum power system that will fit in the shuttle. At an assumed 15% system conversion efficiency, and a heat rejection temperature of 950 K, the maximum power nuclear electric propulsion (NEP) system is about 400 kWe. With this NEP, it is possible to deliver large payloads to circular

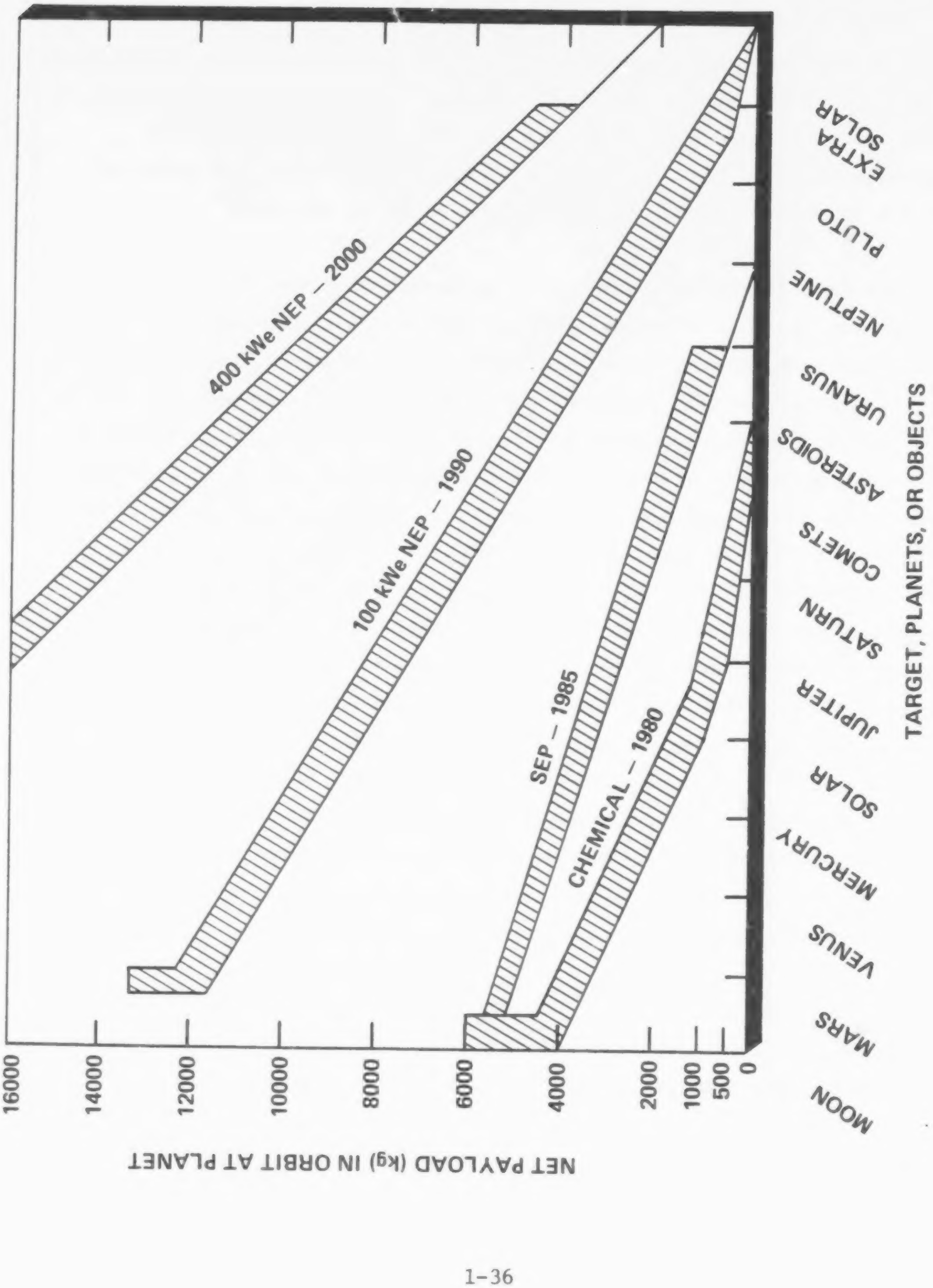

Figure 1.17. Power Levels for Electric Propulsion

orbits of any planet in the solar system with 10-yr mission times or less. Several future military and civil space applications require long life space power systems in the 10-100 kWe range. Since this requirement can be met with low power and low temperature, near term thermoelectric technology is expected to be adequate.

The electric propulsion missions can use the 100-kWe NEP system combined with a chemical stage in one shuttle launch to deliver 1000-8000 kg payloads to the outer planets. The chemical stage would boost the NEP stage and payload to high earth orbit or earth escape. Then the NEP stage would be used beyond earth escape to propel the payload to the target planet. This also allows starting the nuclear reactor in high earth orbit or after earth escape. The early reactor systems could be developed, tested, and used in space without nuclear radiation hazards to the earth. The 100-kWe system can also be used as a single stage from shuttle orbit, without the chemical stage, to deliver larger payloads to the outer planets, or larger payloads to GEO. Therefore, the first nuclear electric power system could be developed at the 100-kWe power level and used for both electric propulsion missions and other missions requiring 10-100 kWe of power in space.

DOE has a two million dollar a year Space Reactor (SPAR) Electric Power Supply Program in which components for a 10-to-100 kWe space nuclear reactor electrical power plant are being designed, fabricated and tested. Such a power plant will consist of: (1) a nuclear reactor for generator heat, including heat pipes for transferring the energy from the reactor to the power conversion equipment; (2) a radiation shield to attenuate radiation to an acceptable level for the payload; (3) thermoelectric (TE) converters to convert heat to electricity; and (4) a radiator for rejecting waste heat to space.

The present design calls for the following characteristics.

POWER PLANT CHARACTERISTICS AT 100 kWe

Efficiency (%)		9
Power (kW_t)		1110
Reactor temp (K)		1400
Radiator power (kW_t)		1010
Shield half angle (deg)		30
Mass (kg)		1755
Reactor	400	
Shield	380	
Converter	285	
Radiator	530	
Structure	160	

Specific Power (Fig. 1.18). The specific power of these nuclear electric systems is based on calculations since none of these systems has been built to date. However, using the present flight-qualified silicon-germanium thermoelectric material and existing reactor and heat-pipe technology, the calculated specific power is about 33 W/kg at the 100-kWe power level. Probable improvements in the thermoelectric materials or thermionics increase the calculated specific power to about 50 W/kg at 100 kWe. Optimistically, if the thermoelectric or thermionic materials now being developed in the laboratory work as predicted, the capability of a 100-kWe system could be 65 W/kg. Using these same materials at the 500-kWe level would result in a power system with a 100 W/kg capability.

Design Life (Fig. 1.19). Design life is defined for purposes of this discussion as the time from mission start to the time when the power output level from the power subsystem has decreased by 20% from its initial power. The thermoelectric materials on Voyager are designed for a 5-yr lifetime and have operated for 3 yr with little degradation in power. Thermionic converters have operated for 5 yr without degradation or failure at a higher temperature than required for this application. The limiting life component at the higher temperature is probably the nuclear reactor fuel element. The goals and component designs are all based on 10-yr lifetimes for electric propulsion.

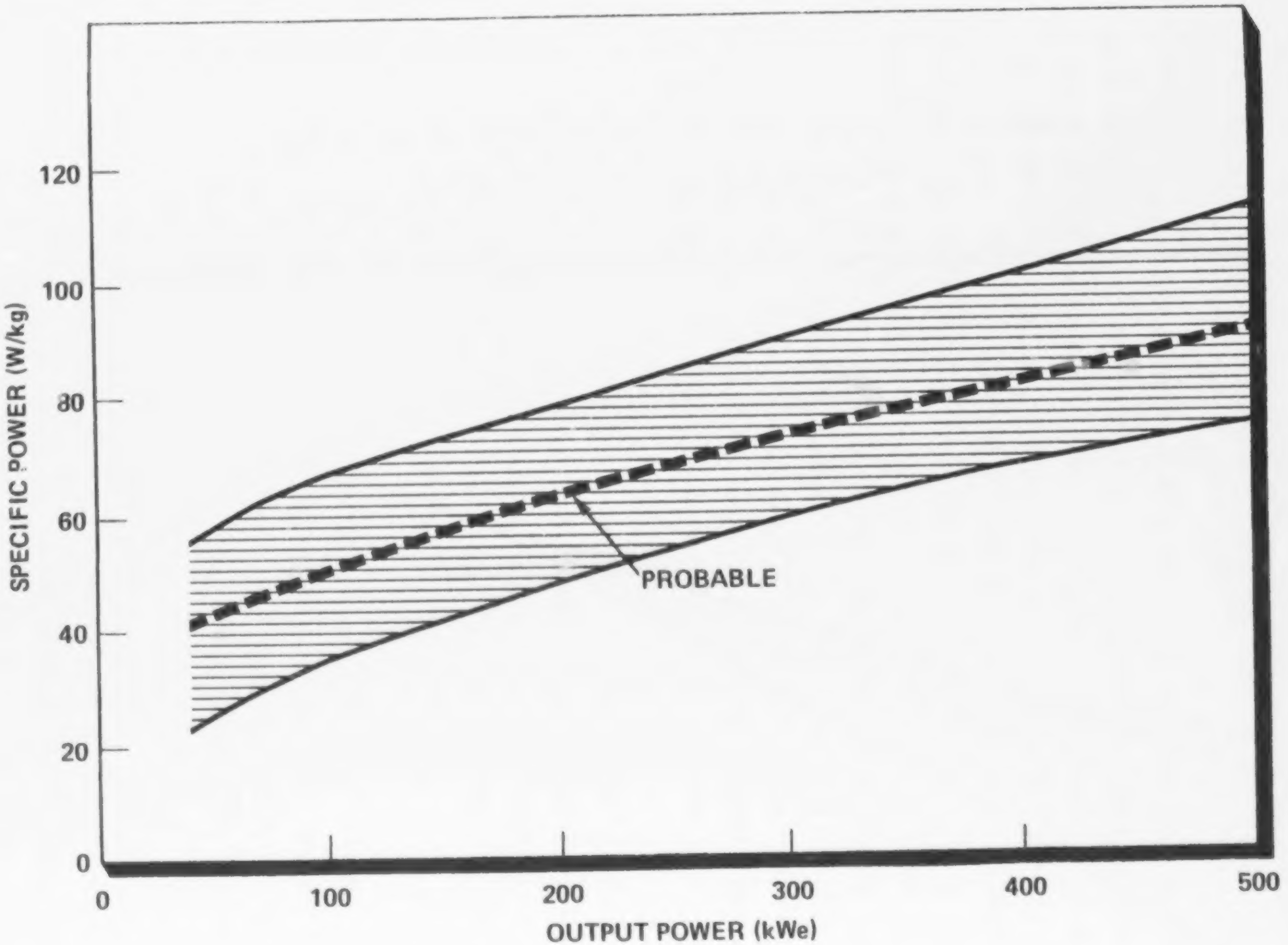

Figure 1.18. Specific Power, Nuclear Thermal-to-Electric Energy Conversion

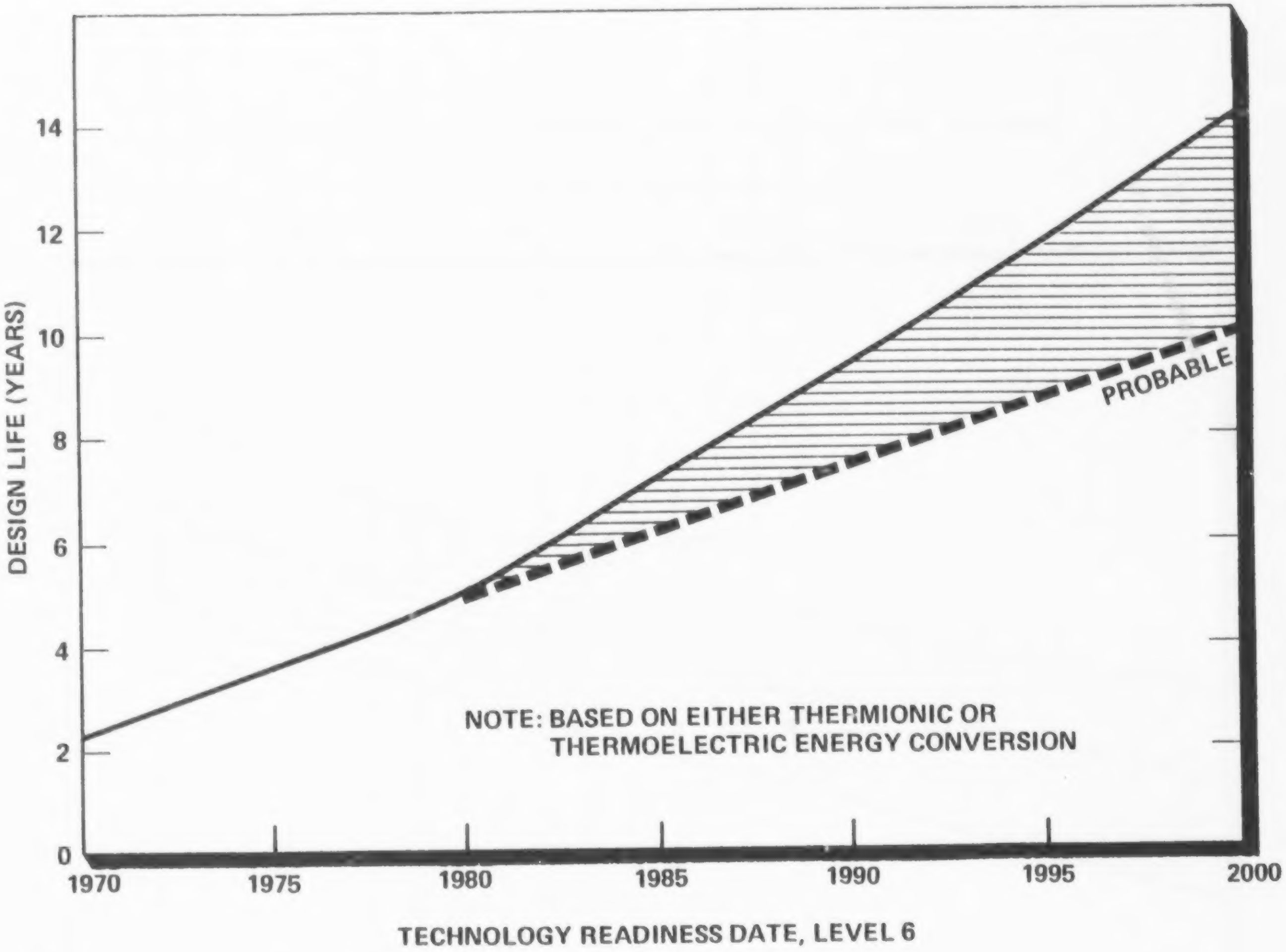

Figure 1.19. Design Life, Nuclear Thermal-to-Electric Energy Conversion

1.3.2 Radiosotope Generators (RTGs & Dynamic Systems)

Advances in RTG technology are measured by three major parameters: increased energy conversion efficiency, higher specific power, and longer lifetimes at the optimum performance level.

Increasing the conversion efficiency is possible through the development of thermoelectric materials exhibiting higher figure of merit (z) as well as increasing the operating temperature difference. A maximum temperature is set by the isotope fuel capability. This is currently 373 K, higher than the thermoelectric material capability. Therefore, the RTG performance can be improved by developing a thermoelectric material with a higher temperature capability, and this is being investigated in the present NASA technology program. A higher temperature material operating at temperatures below its capability can operate for longer lifetimes. Increases in specific power are also possible through the development and use of low density thermal insulation and the use of high strength, low weight structural members such as carbon alloys.

The RTG technology being developed and supported by DOE is concentrating on the fuel, fuel capsule, and thermal electric conversion technologies. The NASA R&T program is directed primarily at improving the conversion efficiency of the thermoelectric materials through increased figures of merit and operating temperatures.

In the thermoelectric materials area, DOE has a 1.5 million dollar thermoelectric program in FY 80 to develop higher efficiency thermoelectric materials by developing new materials, by improving standard materials through modifications such as alloying and by segmenting new materials with existing standard materials.

There are presently three major and three supportive ongoing thermoelectric materials development projects managed by the Power Systems Section of the Advanced Nuclear Systems and Projects Division of DOE. The ongoing projects are:

- 3M - This project utilizes pressure contacted selenide thermoelectrics, the P-leg is Cu_2 Ag Se and the N-leg is Nd Se_x. A thermoelectric material conversion efficiency of 10.5% at the T_H of 850°C is the goal.

- General Atomic - This project utilizes selenide thermoelectric materials segmented with various standard, state-of-the-art thermoelectric materials. The resulting bonded legs will be used in a radiation coupled TRANSIT type converter design. Very light weight as well as high conversion efficiency is the objective sought.

- Syncal - This project is based on bonded silicon-germanium couples in a radiation cooled configuration. The silicon-germanium is modified by the addition of gallium phosphide for the purpose of reducing thermal conductivity and thereby increasing conversion efficiency. A thermoelectric materials efficiency of at least 9.5% in a proven couple configuration at the T_H of 1000°C is the goal.

- Teledyne Energy Systems - This effort is to investigate the fabrication of segmented selenide-TAGS thermoelectric P-type legs.

- Ames Laboratory (Iowa State University) - This work is to investigate the rare earth sulfides and selenides as potential thermoelectric materials. The investigations focus on the method of preparation, electrical, and thermal properties and thermal stability.

- Jet Propulsion Laboratory (JPL) - The objective of this work is to evaluate thermoelectric technology by:

(1) Conducting experimental tests on materials, couples, and modules produced by other contractors to confirm thermoelectric characteristics, thermophysical properties, and long-term stability; and

(2) Conducting long-term life test of electrically heated thermoelectric generators.

A list of calculated RTG parameters based on the segmented selenide thermoelectrics with a hot junction temperature of 750°C and a cold junction temperature of 139°C are as follows:

REFERENCE DESIGN TABLE 1 SUMMARY

Material	
P leg	$(Cu,Ag)_2Se/(BiSb)_2Te_3$
N leg	$GdSe_{1.5}/PbTe$
T_H	750°C
T_C	139°C
Number of couples	748
Number of circuits	4
Voltage/Couple	0.156 V
Electric Power	286 W
Thermal Power	2750 W
System Efficiency (BOL)	10.4%
Voltage	30.8 V
Generator size	
Diameter	26 in
Length	30 in
Generator weight	84.3 lb
Fuel	PuO_2
Fuel form design	GPHS
Design lifetime	5 yr
Specific power (BOL)	3.39 W/lb

The use of selenides, when segmented with other thermoelectric materials, appears to have promise of obtaining higher performance without pushing the temperature limits. It is anticipated that generators of even higher specific power will evolve using this or other advanced technology as a basis.

The specific power for RTGs has increased from 2W/kg for missions during the 1960s and early 1970s to 4 W/kg for the Voyager mission (Fig. 1.20). The specific power for Galileo is 4 W/kg (same RTG as on Voyager). The specific power for the international solar polar mission (ISPM) is 5 W/kg. These are lower than projected since the selenide technology failed to meet its anticipated capabilities. The future projections and goals are based on the successful development of the advanced sulfide thermoelectric materials. Higher specific power levels than those projected are potentially possible only through increasing the isotope heat source temperature capability. Such changes are, however, largely constrained by radiation shielding and safety requirements.

The system conversion efficiency of RTGs has steadily improved (Fig. 1.21). The improvements are due to material advances as well as increased operating temperatures. The future projections and goals are predicated on the development of new thermoelectric materials such as the sulfide system.

The technology goals are 9% system efficiency by 1985, which assumes an improved silicon germanium alloy operating between 1300 K hot junction and 425 K cold junction temperatures. It is projected to have a 15% system efficiency by 1990, with a new thermoelectric material operating between 1375 K (present isotope heat source capability) and 425 K cold junction temperature.

The design life for RTGs is usually dictated by the specific mission requirement. The degradation in output power for any RTG will be determined by the thermal power decay rate of the radiosotope fuel (half power after 87 yr for Pu 238). Many of the RTGs used in the mission shown on the graph of Fig. 1.22 have operated considerably longer than

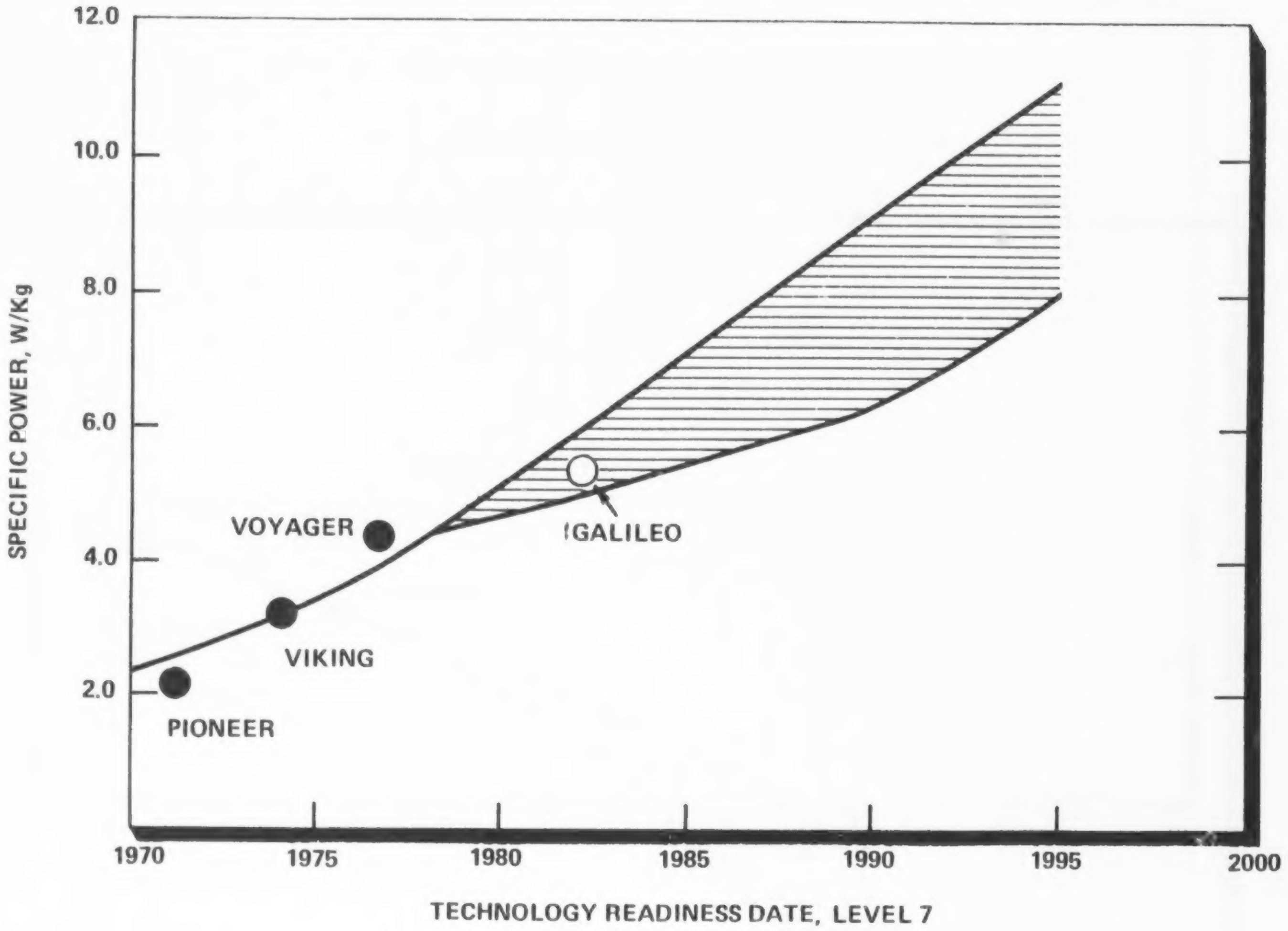

Figure 1.20. Expected Specific Power of Radioisotope Generators for Space Power

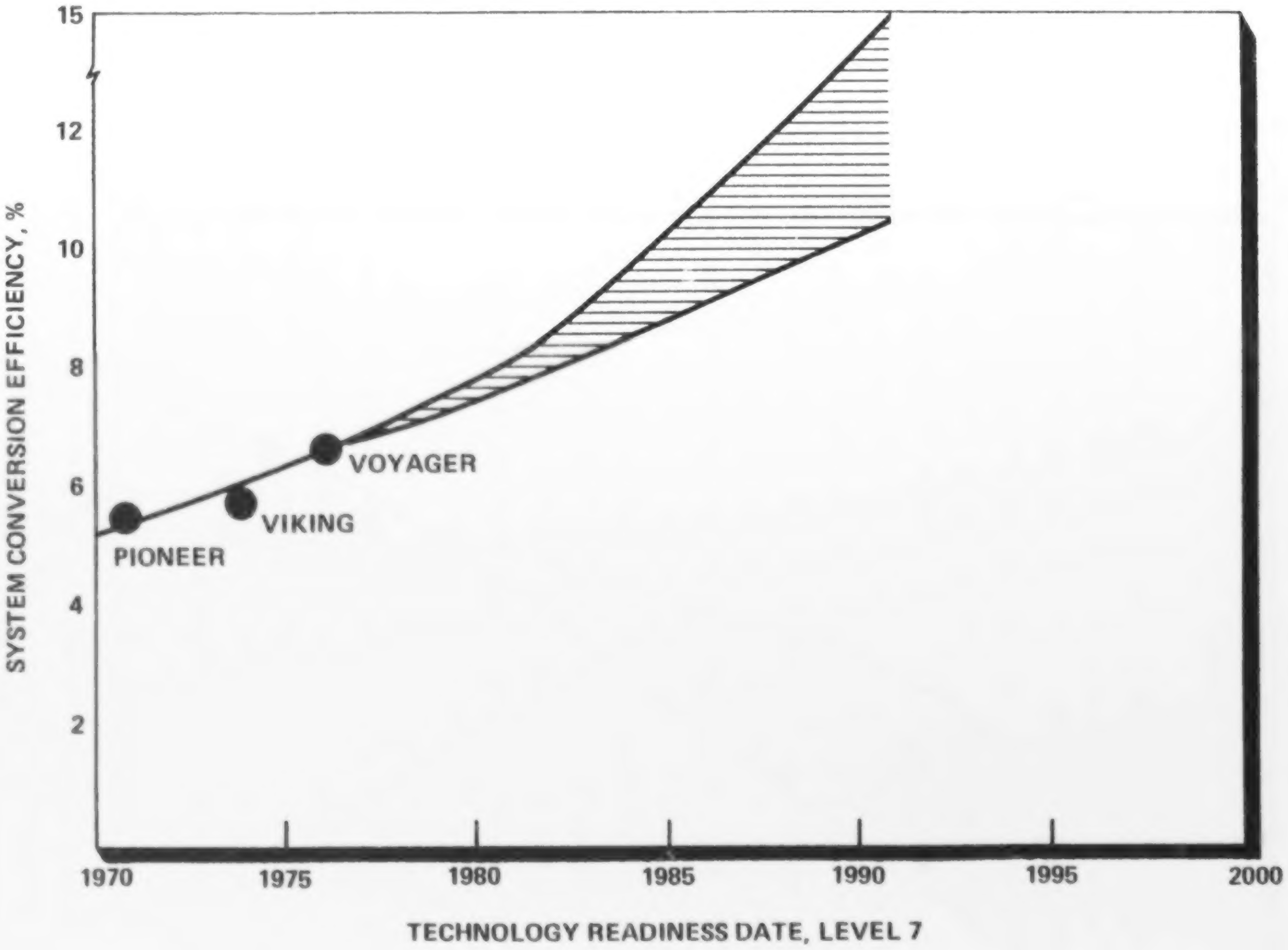

Figure 1.21. Expected Efficiency of Radioisotope Generators for Space Power

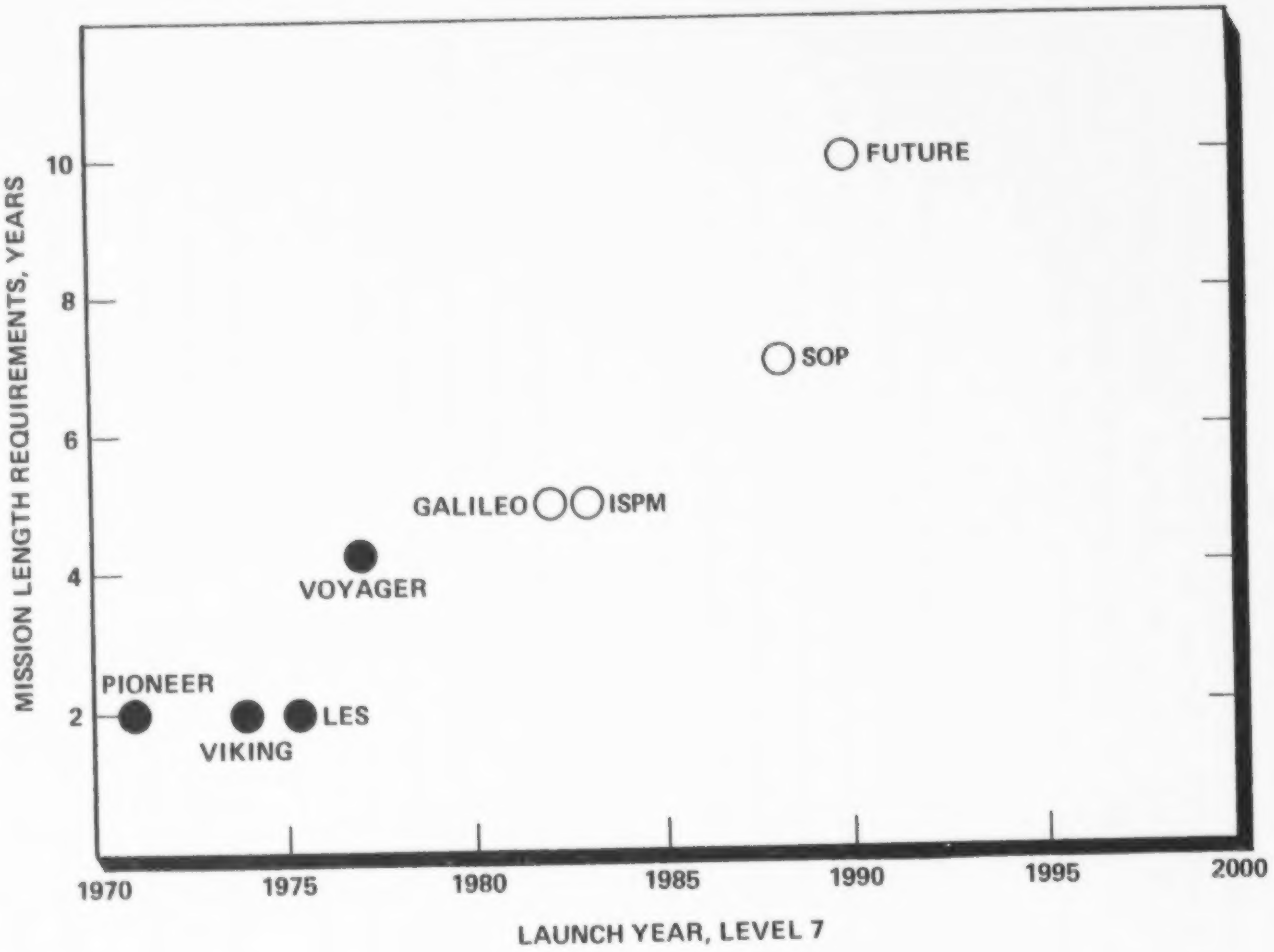

Figure 1.22. Lifetime Requirements for Space Power Missions

their original design life requirements. For most application, thermoelectrics can be designed to match the isotope fuel lifetime, but only at the expense of specific power and efficiency, simply by decreasing the operating temperatures. The operating lifetime of a given RTG is directly related to the hot junction operating temperature. Higher temperatures reduce RTG lifetimes due to higher material sublimation rates, diffusion rates, interaction rates, etc. A design life of 10 yr, as shown on the graph, is based RTGs designed for maximum specific power and efficiency, with a 20% reduction in power out at the end of the 10-yr life.

The specific cost of RTGs cannot be realistically assessed at present. In part, this is due to uncertainties in government-controlled fuel costs as well as developmental costs (which are primarily funded by DOE). Per interagency agreement, NASA traditionally uses the first RTGs for any mission free of cost and pays for the use of any additional ones. The cost of the RTGs that NASA buys is based on the total DOE development costs divided by the total number of flight type RTGs that DOE produced during development.

Considerable past effort was expended by both NASA and DOE to develop the technology for dynamic isotope power systems at power levels ranging up to 10 kW. Both Brayton and organic Rankine cycles were pursued. In the face of an expected near term military flight requirement, the organic Rankine system was selected for further technology verification in a DOE program.

The Department of Energy has also funded application studies for assessing the integration of the organic Rankine power system into various potential DOD spacecraft missions. These studies indicate that the pumped liquid loop feature of the Organic Rankine Dynamic Isotope Power System (DIPS) can offer significant protection of a satellite against certain hostile threats. This is in addition to its other inherent attributes such as:

- Increased user power
- Extended mission duration
- Improved orbit prediction
- Spacecraft thermal control enhancement
- Orbit/orientation insensitivity

The current Department of Energy program (two million dollars in FY 80) is planned to be completed on 1 October 1980. The flight system objectives are defined as follows:

Power	1.3 kWe
Voltage	28 V DC
Lifetime	10 yr
Reliability	0.95
Weight	≤450 lb for a non-integrated system - includes power conversion system, heat source assemblies with isotope and space radiator

1.4 POWER SYSTEMS MANAGEMENT AND DISTRIBUTION

W. R. Hudson, NASA Headquarters

The power systems management and distribution technology program is advancing on a broad front to provide the basic technical understanding necessary to assure environmental compatibility and to control the generation and distribution of energy in future space systems. The program seeks to develop critical components, circuits, and subsystems which permit the simultaneous achievements of low-cost, high-power space energy systems. The interaction of the space plasma environment with high voltage systems, spacecraft, and large space structures is also being investigated. To date NASA has launched individual spacecraft with at most a few kilowatts of power-generating capability. The cumulative total solar power generating capability launched to date is approximately 100 kW. There are many missions on the planning horizon (just beyond the 5-yr plan) that require large increments in space power. Figure 1.23 depicts the two classes of demand that were identified in the 1979 space power cross-cut study. The historical average cost of space energy systems has been very high: in the range of $1000/kW-h. For the projected missions to be feasible, unit energy costs must be reduced by a factor of 10 to 100.

A key element of future high power space systems is the development of components such as power transistors, switches, and capacitors. The recent development of high-voltage switching transistors in the range of 600 V and 100 A is a good example. This program is continuing and doubling of both the voltage and the current is projected by the end of FY 1983.

Another example is the heat-pipe-cooled transformer. At higher power levels, heat-pipe-cooled components have the potential for greatly reducing mass, increasing operating life, and raising the upper limit of power handling capability. For a 2.4-kW heat-pipe-cooled transformer, 40% less mass was required than a standard conduction-cooled transformer. It also operated at 20°C lower mean winding temperature, and lower temperature implies longer operating life.

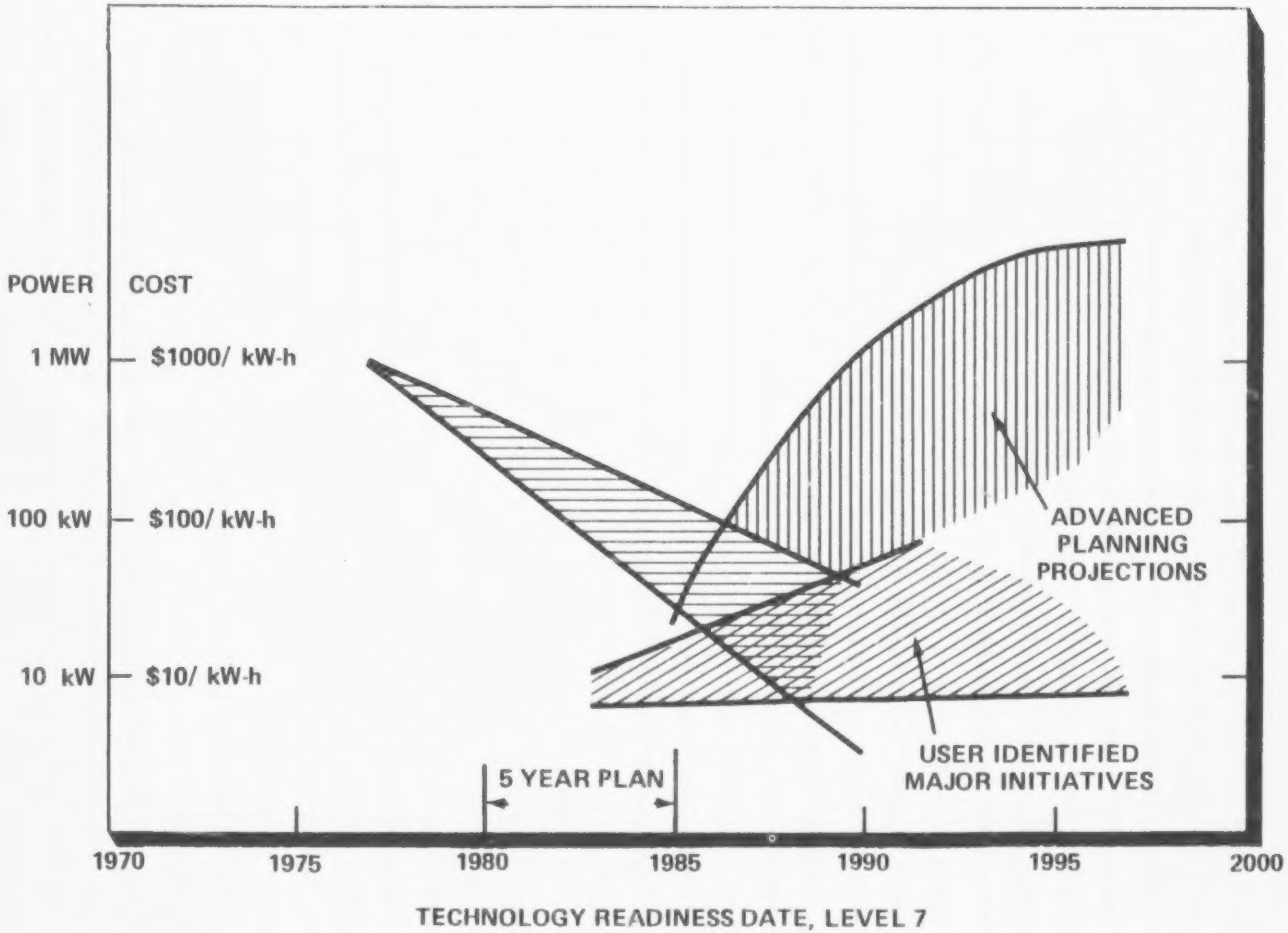

Figure 1.23. Projected Space Power Demand

These are just two examples of component technology programs. Other areas include lightweight, high voltage capacitors, solid-state switch gear, power MOSFETs, and rotary power transfer devices.

An important subelement of the power system management area is high-power circuit technology. This area includes circuits for power inverters and converters. A program goal of 1 kg/kW for high-power conversion equipment has been set. Three basic types of inverters and converters are presently being explored: the series-resonant inverter, the capacitor diode voltage multiplier, and the conventional converter.

Future missions will require the capability of a spacecraft power system to automatically perform monitoring, computation, command, and control functions without the need for ground intervention. Future outer planetary exploration missions will result in long round-trip signal time delaying or preventing proper power system management from earth. Fabrication of an automated power systems management breadboard has been completed and it is currently undergoing functional verification tests at the Jet Propulsion Laboratory. The objective of the effort is to demonstrate the capability of a spacecraft power system to automatically perform monitoring, computational, command and control functions.

For missions in hostile environments special power systems may be required. An orbiter of Mercury is one such mission. Because silicon solar cell technology is not viable in the expected high-temperature environment, solar thermoelectric generators are being examined as a possible power source. Current designs under study would provide 350 W at 0.45 A with an area of 3.24 m^2 and a mass of 19.8 kg.

Environmental interaction is also part of the power management and distributions program. This includes efforts in spacecraft charging and in the interaction of high voltage systems with the ambient space plasma environment.

The present distribution voltage (Fig. 1.24) for the Shuttle Orbiter is 28 V. The major driver for distribution voltage is the conductor weight required to carry high currents. Figure 1.25 shows the strong inverse dependency of power distribution weight on voltage for a 130-kW system. To be feasible, the distribution voltage must be in the vicinity of 300 V. Note the relative insensitivity of power conditioning and switch gear mass to system voltage.

Any prediction of future distribution voltage is then almost predetermined by the system power level and size (length of conductor runs). Up to 1-kW power levels, 28-V distribution is practical. At 10-kW levels, it becomes necessary to increase the voltage to 120 V (about household levels). In like manner, at 100-kW power level the voltage increases to 300 V and at 1 MW it increases further to 1000 V. The NASA program to develop components and circuits has focused technology development on these three voltage levels. One further consideration is that between 500 V and 1000 V the interactions of high-voltage systems with the space plasma become a concern at low altitudes (relatively high plasma densities).

There are two basic power distribution systems under study for power distribution on multi-hundred kilowatt systems: AC and DC. On a life-cycle cost basis, the two approaches are approximately equal; the AC costs are projected at $0.32/kW-h, and the DC costs are $0.40/kW-h. For comparison purposes, the power management system for Halley Class solar electric propulsion system was $32/kW-h.

As discussed in a previous paragraph, bus weights are a strong inverse function of voltage. Therefore, it follows that transportation-to-orbit costs decrease with voltage. As shown in Fig. 1.26, the hardware costs rise slowly as voltage increase. In addition, efficiencies improve and component losses are reduced, thereby reducing the cost of solar array components and batteries. Figure 1.26 also shows that the function has a broad minimum for multi-hundred kilowatt systems, and a voltage of 1000 V seems like a good number for further development work.

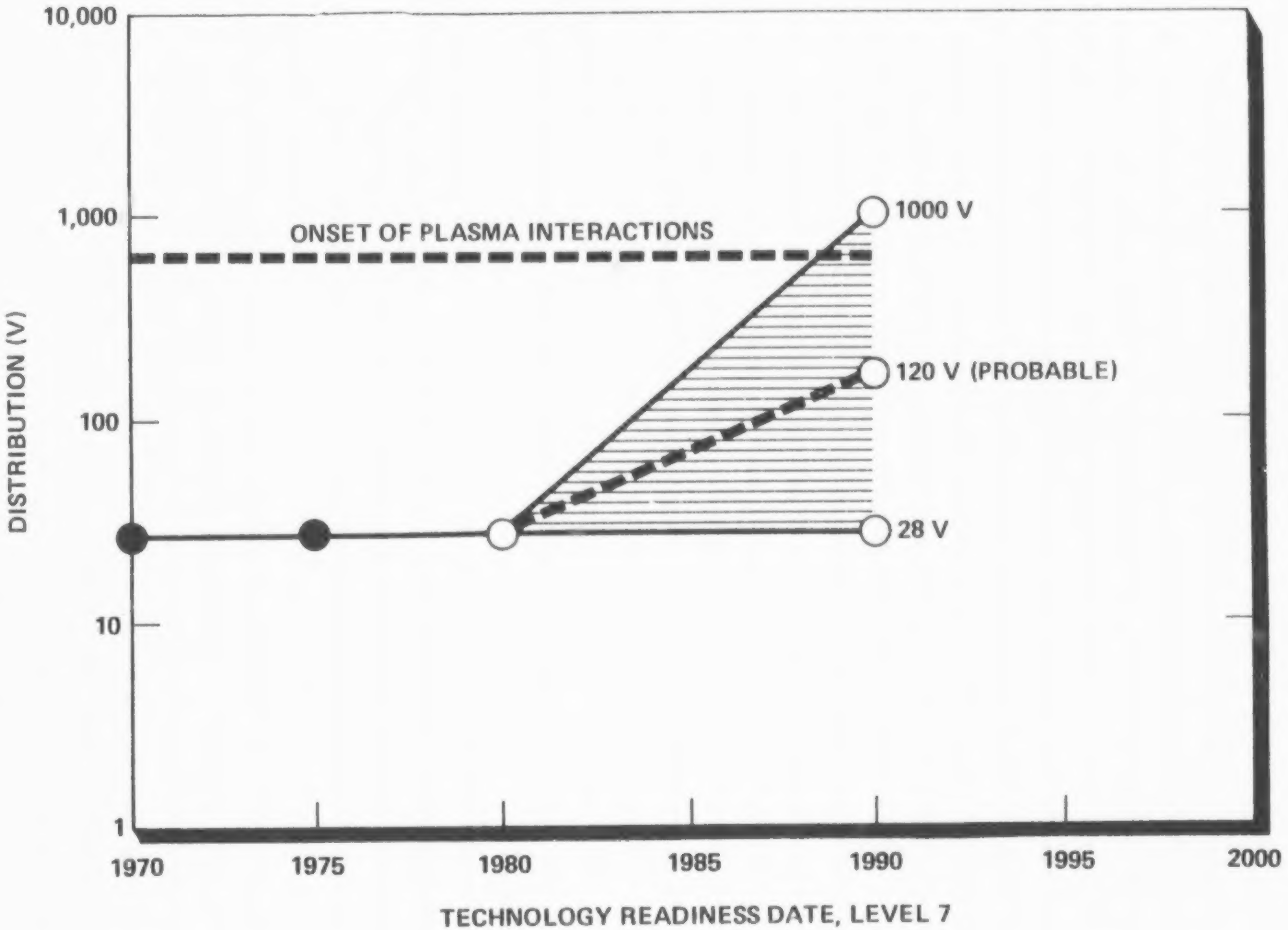

Figure 1.24. Power Distribution Voltage

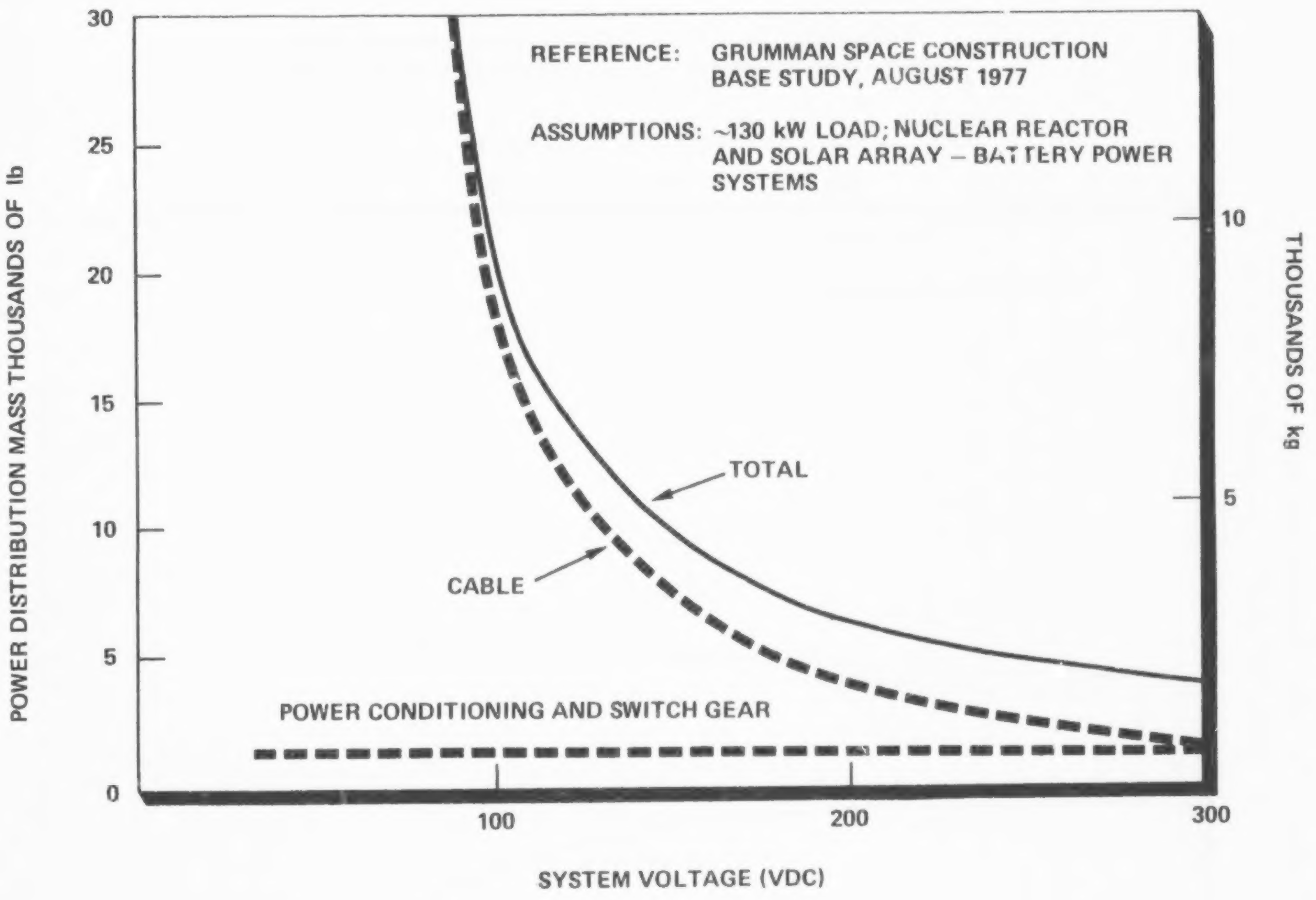

Figure 1.25. Power Distribution Mass vs. System Voltage

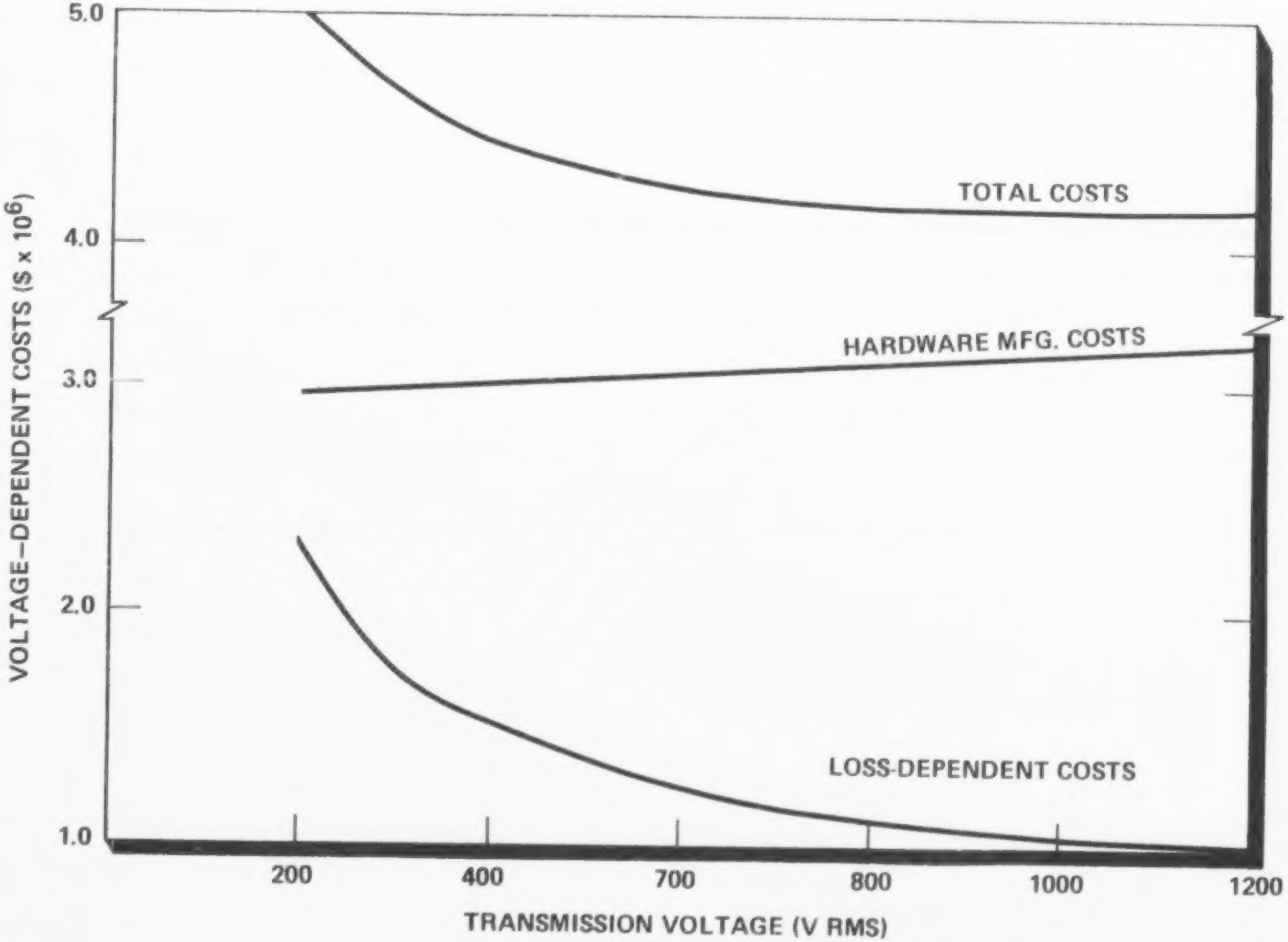

Figure 1.26. Power Management System Voltage Dependent Costs
(High-Frequency AC Distribution, "Mil. Grade" Components)

Another important parameter for power management cost is the transmission frequency. Figure 1.27 shows the hardware cost and transportation-to-orbit cost as a function of frequency. Production cost initially decreases with frequency and then rises due to special high frequency consideration in the construction cost. Weight and transportation costs decrease rapidly with increasing frequency. It has been determined that maintenance costs are not significant. As can be seen from the curve, the most effective frequency lies between 20 and 26 kHz. Human engineering considerations require that frequencies be above the audible range (20 kHz has been established as the minimum allowable frequency).

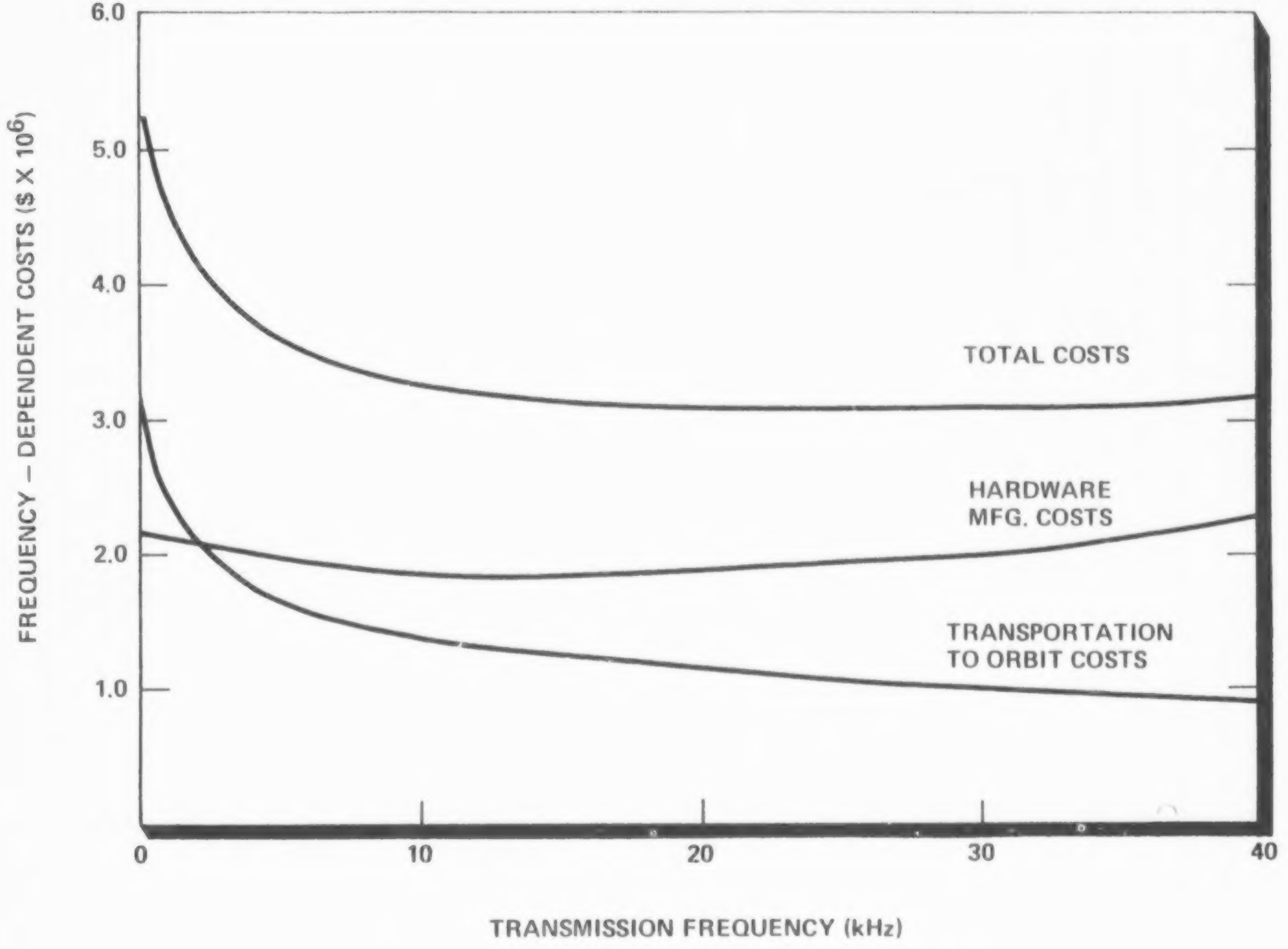

Figure 1.27. Power Management System, Frequency-Dependent Costs (High-Frequency, AC Distribution, "mil. grade" Components)

1.5 ELECTRIC PROPULSION

Wayne Hudson, NASA Headquarters

The NASA Electric Propulsion Research and Technology program is directed toward providing the technology base to meet the nation's future needs in the area of low thrust, high specific impulse propulsion.[1-5]

For the energetic mission[6-9] included in NASA's plan for exploring the solar system an electric propulsion system (Fig. 1.28) will be needed to augment the Shuttle-IUS Space Transportation System. Some of the missions under study include: comet and asteroid rendezvous, Saturn orbiter with probes, Mercury orbiter, and Mars surface sample return. Detailed mission analysis has shown that electric propulsion is readily able to provide larger payloads, shorter trip times, more mission flexibility (i.e., launch any year to Jupiter) and less complicated trajectories (i.e., no gravity assists for Mercury orbiter).

Studies have also demonstrated that solar array power can be constructively utilized after the propulsive portion of a mission has been completed. For example, on planetary orbiter missions, the array power capability (anywhere from 1 kW to 100 kW) could be used for radar systems, laser systems, and increased communications capability.[10]

Earth orbital mission studies have identified several potential uses of electric propulsion. The one millipound auxiliary thruster has been developed specifically to demonstrate the technology for north-south stationkeeping of geosynchronous satellites. The longer the operation life of the satellite (the greater the total impulse), the greater the savings in propellant mass that can be realized from using electric propulsion. For example, on a five-year stationkeeping mission, the use of auxiliary electric propulsion can provide 15-20% of the total spacecraft mass for extra payload. Another auxiliary propulsion application of ion thrusters could be to provide orbital control of future sun-synchronous satellites (i.e., the next generation Landsat). In this application the orbital control function consists of either maintaining a

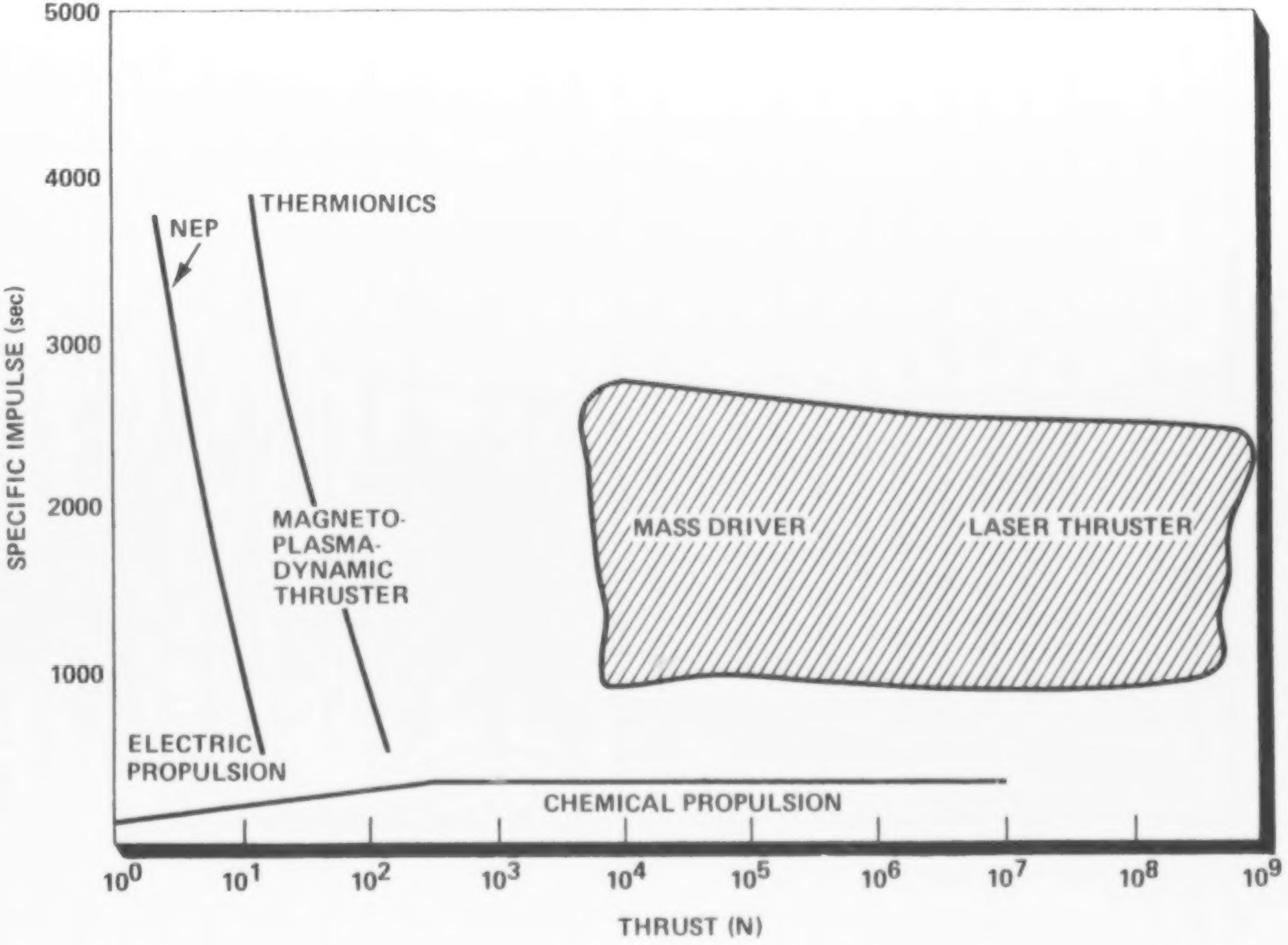

Figure 1.28. Specific Impulse vs. Thrust

precise sun-synchronous orbit or programming an orbit change. The on-board solar array power required for electric propulsion might also be used to advantage for earth orbital applications. A second generation Landsat that utilized a multikilowatt solar array would have its capabilities enhanced considerably.

In addition, larger ion thruster systems have been studied for orbital transfer of large payloads or very lightweight structures. The more efficient utilization of propellant that results from high specific impulse of electric propulsion represents a major logistics benefit for any earth orbital scenario that requires large amounts of propellant transported to orbit. Although NASA's large space systems program is in the embryonic stages, it might well require electric propulsion for orbital transfer of large delicate structures and for on-orbit stationkeeping and attitude control.

1.5.1 Program Status

At this point in time, the one millipound auxiliary thruster is midway through the fabrication of flight hardware. The NASA Office of Space Transportation has initiated the Phase B for the development of a solar electric propulsion stage. Within the technology program we have initiated an ion thruster extended performance effort: to expand the specific impulse operation range, to increase thrust to mass, and to operate efficiently with inert gases. The preliminary technology steps are being taken to eventually develop nuclear electric propulsion. Advance propulsion concepts such as the magnetoplasmadynamic (MPD) thruster and the mass driver are being evaluated.

Auxiliary Thruster

The objective of the auxiliary propulsion technology program is to develop a prototypical one millipound electron bombardment thrust system and subject it to flight qualification level testing. Since the last Electric Propulsion meeting, the launch date for Air Force Space Test Program P80-1 mission has slipped to mid 1982 because of delays in the prime experiment. The ion thruster system, however, will be delivered in November of 1980.

The ion thruster flight package consists of two thruster subsystems and a diagnostics instrument subsystem. The 8-cm thrusters operate at a specific impulse of 3000 s, require 180 W, weigh 26 kg, and develop a thrust of 1 mlb. One thruster will operate cyclically to demonstrate the durability of the subsystem over a simulated 7-yr north-south stationkeeping mission on a typical geosynchronous satellite. The other thruster will be used for special purpose testing.

Primary Thruster

The objective of the solar electric propulsion base-line program is to demonstrate the technology readiness of high specific impulse (3000 s) ion thruster propulsion by the end of 1980.

During 1979, both ion thrusters and power processing units were fabricated and acceptance tested. Currently, they are being assembled into the bimodular thrust subsystem (BIMOD). The BIMOD consists of two thrusters, two power processors, thruster gimbals, and a heat pipe thermal rejection system.

The principal tasks associated with the base-line technology program include a mission profile life test, a thruster endurance test, power processor development, and thrust subsystem module development.

Magnetoplasmadynamic Accelerator

Three years ago a thorough evaluation of the quasi-steady state MPD was initiated to evaluate the viability of this technology for future orbital transfer vehicles and interplanetary transportation. Although the physics associated with the MPD is somewhat more complicated than that associated with electron bombardment thrusters, the MPD offers the potential of higher thrust density and increased power processing simplicity. The thrust per unit exhaust area is 10^4 times greater than the bombardment thruster. As a result the MPD could replace an array of ion thrusters. Inherently, the MPD technology is predicted to perform better at higher power levels and at somewhat lower specific impulses. Instead of twelve power supplies, the MPD will require only two or three. Furthermore, the MPD has no requirement for neutralization such as the bombardment thruster. Two important problem areas that need to be addressed in the quasi-steady state MPD are the appropriate electrical pulse formation and the necessary propellant pulse control.

The 1981 goals of the program are to determine if the recent breakthrough in the understanding of the fundamental physical mechanisms of the MPD can be manifested in thruster performance and life. Continuing fundamental research at Princeton University projects thruster efficiencies up to 50% at specific impulses in the range of 1000-5000 s. The evaluation program is being carried out at Princeton University under the technical cognizance of the Jet Propulsion Laboratory. A thrust stand for the performance characterization is currently being constructed. The thrust stand will be capable of time resolved (<100 msec resolution) measurements of thrust.

Nuclear Electric Propulsion

Nuclear electric propulsion (NEP) is a significant option for future transportation in the solar system. It has the potential for constant power independent of solar intensity, it is inherently a long life technology, it does not suffer from radiation damage, nor does it require ancillary energy storage systems or precision solar tracking systems. NEP will eventually be needed by NASA to successfully complete the intensive study of the outer planets of the solar system. It also would have many advantages as a future orbital transfer system. The nuclear reactor that would be developed for NEP would have many other applications such as: earth orbital platforms, lunar and planetary bases, and planetary orbital research stations.

The principal components of a NEP system are the reactor, the thermal-to-electric conversion system, and the electric thrusters. Some work is being done in each of these areas. The thruster technology program is described in detail elsewhere and the overall systems studies have been initiated at the Jet Propulsion Laboratory.